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5. meat ⑥ accessory foods
7. food wastage ⑧ cooking
9. meal frequency
10. light industry (FW)
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INDUSTRIAL NUTRITION

1912

INDUSTRIAL NUTRITION

BY

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PREFACE

DURING recent years interest in the relationship between the nutrition of industrial workers and their health and efficiency has greatly increased. Study of the feeding of workers is not, however, a new development. In 1924, when unemployment was widespread, the Medical Research Council [1] investigated the adequacy of the diet of coal-miners and their families; and in 1936 the International Labour Office issued a report [2] on workers' nutrition and social policy. The practical importance of the application of nutritional principles to the conditions existing in industry was greatly increased in Britain when, in November 1940, the Factories (Canteens) Order was passed directing any factory employing more than 250 people to make satisfactory arrangements for the establishment and maintenance of a suitable canteen where hot meals could be purchased by the factory workers. The Order was at first applied only to factories engaged on munitions work, but in April 1943 it was extended to cover all factories doing work considered to be in the national interest.

Those responsible for the well-being of industrial workers quickly appreciated that the provision of adequate meals, designed to ensure that the total daily diet of each worker was nutritionally adequate for his needs, was not only an important forward step in social practice, but was also calculated to increase industrial efficiency. To-day very many factories maintain canteens of their own free will.

[1] Medical Research Council, 1924. Sp. Rept. Ser. 87.
[2] I.L.O. 1936. Studies and Rept. Ser. B. (Econ. Conditions), 23.

A number of books have been published describing how industrial canteens should be run and giving instructions on efficient and economical methods of cooking and of preparing meals. Although some of these books briefly review the general principles of nutrition, there does not at the present time appear to be in existence any reasoned discussion of the special nutritional needs of people working under the practical conditions of industrial life to-day. Dietary customs and habits vary widely in different parts of the country and between one industry and another. Behind all these different dietary patterns, however, lie the basic principles of nutritional science. In this book I have tried to review the available evidence showing how the different types of work carried out by people of different ages and of the two sexes affect their nutritional requirements, and how meals can best be arranged within the varied conditions of industrial life to provide different groups of people with their nutritional needs. This discussion may perhaps provide something of value to all those who have an interest in, or who are responsible for, industrial workers to-day, as well as to those who are students of nutrition. In particular, I hope that it will be useful to the many hundreds of industrial caterers who during the past ten years and more have consistently shown their interest in acquiring a knowledge of the principles upon which their practice must be based if it is finally to be successful.

As these words are being written, the subject of industrial nutrition is of critical importance in this country. During a period when the British food supply has been consistently exiguous, the long-drawn effort to increase the efficiency of the worker and the output of industry continues unabated.

Some of the work described in these pages was carried out when I had the advantage of the stimulation of daily

contact with Sir Jack Drummond, F.R.S., and I should like to acknowledge his encouragement here. My thanks are also due to Miss D. Johnston, Deputy Chief Inspector of Factories, who was always ready to give me friendly advice and assistance. I must acknowledge the technical co-operation of my late colleague, Miss M. Ainslie.

M. P.

Blairlogie.
December, 1949.

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Chapter One

GENERAL PROBLEMS OF INDUSTRIAL NUTRITION

FEEDING in industry and the problems of industrial canteens cannot be considered separately from the more general subject of human nutrition as a whole. One of the mistakes of the Industrial Revolution has been that the workers in a factory or the miners in a pit have in the past been thought of as if, once they were at work in the large numbers necessitated by modern industrial life, they had become a special species of being, different from an ordinary person. Even to-day "factory meals", "the works canteen" or "the mid-shift snack" are sometimes studied as problems on their own and not, as they must be, as part of the diet of men and women who happen to spend some of their day at a particular job. In a moment we shall, perforce, be discussing the scientific aspects of nutrition as they affect the industrial worker, but before we do so we must take, as the first principle of successful catering, the fact that workpeople in factories, whose nutrition we are proposing to consider, are first of all *people*. It is painfully easy to find oneself thinking of two dozen of one's fellow-creatures as twenty-three "joints" and a "fish pie".

Industrial nutrition is concerned with the feeding of people. If, then, the first principle of the successful application of scientific nutrition is to remember that the subject

applies to *people*, the second principle is that nutrition depends on *food*. An infinite variety of diets, composed of a multitude of types of foods cooked in many different ways, are to be found among the peoples of the world. Some of these diets are nutritionally adequate for health, and some of them are not. " A little of what you fancy does you good " may sometimes be true, but it is very often not so. Some of the men and women who filed into the Armed Forces in the nineteen-forties could claim to possess perfect nutrition, but very many of them could not. To-day those same men and women, and others like them in factories, mines, docks and workshops, still show signs of a nutritional status capable of improvement. And, furthermore, they are each day in need of a diet sufficient to enable them effectively to meet the demands of their day's work. An appreciation of the principles of nutrition and an understanding of how such principles can be applied under industrial conditions can alone enable this need surely to be fulfilled.

Human nutrition is a branch of applied physiology. As such it is a science that takes no account of the subjective feelings of the people being fed. While it is true that " man does not live by bread alone ", it is equally true that the nutritional well-being of the animal species *homo sapiens* is as little affected by his likes and dislikes as are the nutritional requirements of experimental rats confined in a laboratory. From the rigid standpoint of animal physiology, the average nutritional requirements of groups of people are fixed, and are based on such measurable characteristics as sex, age, height, weight, degree of activity, rate of growth and sexual maturity. Furthermore, when average groups are considered, there are no exceptions to the laws of physiology. The nutritional needs of similar individuals are the same wherever in the globe they happen to live and

whatever type of diet they may happen to be accustomed to eat.

The nutritional needs of similar individuals are the same, but their customary diets may be very different. The variety of diets eaten in different parts of the world is infinite. Many groups of people subsist on inadequate diets, and suffer in consequence. But it may happen that diverse diets equally well provide the nutritional needs of those eating them.

For example, in 1946 a study[1] was made of the state of nutrition of the Otomi Indians in the Mezquital Valley in Mexico. The health of these Indians was found to be good, yet they were eating very few of the foods usually considered in the Western world to be necessary for a good diet. They ate little meat, dairy produce, fruit or vegetables. Instead they made their meals from tortillas and from local plants such as malva, hediondilla, tuna, nopales, maguey, garambullo, yucca, purslane, pigweed, sorrel, wild mustard flowers, *lengua de vaca*, sow-thistle and cactus fruit. And they drank pulque, an intoxicating beverage made from the juice of the century plant. Yet when the components of the Otomi Indians' diet were flown to the Massachusetts Institute of Technology and analysed,[2] it was found that they provided a better nutritional balance than was present in the diet of a group of United States town-dwellers surveyed at the same time.[3]

The lesson to be learnt from this by the student of industrial nutrition is that, no matter how unusual a traditional diet may appear, it ought never to be condemned until its nutritional composition is known. It is upon this basis alone that nutritional adequacy can be assessed.

[1] Anderson, Calvo, Serrano and Payne, 1946, *Amer. J. Pub. Health*, 36, 883.
[2] Gravioto *et. al.*, 1945, *J. Nutrition*, 29, 317.
[3] Lockhart *et al.*, 1944, *J. Amer. Dietet. Ass.*, 20, 742.

Although nutrition makes itself felt in terms of food, a soundly based diet cannot be established in terms of beefsteak, bread, doughnuts or any other food. It must first be expressed as nutrients.

A food can be defined as anything which when digested can do one or more of three things: (*a*) furnish the body with material from which it can produce heat, work or other forms of energy; (*b*) provide material to enable growth, repair or reproduction to proceed; (*c*) supply substances which normally regulate the production of energy or the process of growth, repair or reproduction. *Nutrients* are the components of foods which enable them to exert one or other of these functions, and hence to be defined as food.

The most fundamental of the three attributes of food is the provision of energy. One difference between a living body and a dead one is that the temperature of the living body is maintained, its muscles exert a positional tension even during sleep, blood circulates and breathing continues. Energy is required to keep the bodily machine "ticking over" thus. It was Lavoisier who in Paris at the end of the eighteenth century first established that the human engine, like any other mechanical machine, obeys the laws of thermo-dynamics. He also observed that the energy used up by the body was derived from food.

It requires about 70 calories of energy an hour to keep the basal functions of an average man's body going. The exact amount needed by an individual is proportional to his body-size. It is largely for this reason that whereas an average man consumes 70 calories an hour in keeping himself alive, an average woman, being smaller, uses only about 60 calories an hour.

These are the requirements for "ticking over" only. When the machine is "put into gear", additional fuel is

consumed. Merely to sit requires 15 calories an hour over and above the basal metabolic needs; to stand requires an extra 20 calories an hour; walking at moderate speed uses 200 calories and climbing stairs 1,000 calories an hour. The varied activities of a sedentary man when added to his basal requirement call for a daily expenditure of about 2,500 calories. A sedentary woman needs 2,100 calories daily. Manual workers expend from 3,000 to, say, 4,500 calories, depending on the arduousness of their jobs. If people do not obtain from their diet the calories they need, three things happen: (*a*) they become hungry, (*b*) they do less work and (*c*) they consume the substances of their body and become thinner.

Just as it is possible to determine the calorific value of different specimens of coal when comparing their qualities as fuel, so can the calorie value of different foods be measured so that they may be compared as sources of energy. An ounce of butter provides 212 calories, an ounce of sugar 108, an ounce of bread 70, of potato 25 and of cabbage—a watery food—7 calories. The first measure of the adequacy of the diet for a man is the comparison of the calorie requirements of the individual, or of the several groups comprising the working population, with the total calorie content of all the different commodities making up the daily diet.

The fundamental feature of a planned diet must be that it shall make provision for there being enough to eat—that is to say, for an adequate supply of calories. The second feature is that the foods providing the calories shall be selected so that a practical meal can be constructed from them. For example, in times of difficulty an Irish peasant can subsist almost entirely on potatoes. Since an ounce of potato provides 25 calories, it is necessary for a moderately active man, whose total needs are, say, 3,000 calories a day,

to eat 120 oz. of potatoes in a day, or, say, $2\frac{1}{2}$ lb. at each of three successive meals. This is inconvenient, to say the least, for an industrial worker. The second aspect of the planned diet, therefore, so far as calories are concerned, is the recognition of the differing energy value in fats, sugar, cereals, meat and other food commodities.

The analogy between the animal body and a mechanical engine cannot be taken too far. Although the production of mechanical energy is a primary function of food, it is not the only function. The components of muscular tissue, of bones, of teeth and of blood must all be derived from food. The nutrients serving these purposes are, first, proteins and their components, to be found in animal foods such as milk, meat, fish and eggs and, though often in less favourable proportions, in cereals and other vegetable foods. Mineral elements, notably calcium, iron, phosphorus and many others, from which such special structures as bones, teeth and blood-cells are built up, must also be derived from the foods comprising the diet.

Finally there are a number of complex enzymes needed by the body to maintain in action the slow-combustion processes of life. Many of these enzymes can be built up by the body from the basic chemical elements of which foods are composed, but, on the other hand, certain of them cannot be elaborated unless important sections are available "pre-fabricated" in one or other of the foods comprising the diet. These pre-fabricated sections are the *vitamins*.

The diet of a man must therefore provide sufficient energy for life and work, and it must also supply nutrients such as protein, fat, calcium and iron, from which the body-structure is composed. Finally, it must supply the quantitative needs of a series of vitamins and other accessory food factors.

The requirements of every category of individual in terms

of nutrients are known. In 1935 a technical commission of the League of Nations [1] drew up a table of the nutritional needs of children, adults, workers and adolescents and other special groups such as expectant and nursing mothers. This table was gradually modified and extended as scientific knowledge became more complete, until to-day, after estimates published in 1943 had been revised first in 1945 and then in 1948, the recommended nutrient allowances of the Food and Nutrition Board of the U.S. National Research Council [2] can be accepted as the amounts of the different components of which a diet is made up which will certainly produce optimum nutritional health. Many individuals can consume a diet providing less than the National Research Council recommendations and still be adequately nourished; no group of people, however, would benefit from being given more. The allowances for those categories of folk in whom the industrial nutritionist is interested are shown in Table 1.

The usefulness of a knowledge of nutrition to people who are responsible for feeding industrial workers rests on its enabling them, first, to draw up just such a table as that shown overleaf; and secondly, in giving the information as to which foods and how much of them must be included in a diet so that it may provide the amounts of necessary nutrients.

The most direct way in which industrial work affects the nutritional requirements of the worker is through its calls on the body for physical energy, and hence its demand on the diet for calories. This is an important practical matter which has not been adequately studied under practical conditions. The scientific literature contains a considerable

[1] "Report on the Physiological Basis of Nutrition", 1935, Geneva, Pub. iii, Health, 6.

[2] U.S. National Research Council, Reprint and Circular Ser. No. 115, 1943; 122, 1945; 129, 1948.

TABLE I

Recommended Daily Dietary Allowances

	Calories	Protein, g.	Calcium, g.	Iron, mg.	Vitamin A, i.u.	Vitamin B[1], mg.	Riboflavin, mg.	Niacin, mg.	Vitamin C, mg.	Vitamin D, i.u.
Men (weighing 154 lb.)										
Sedentary	2,400	70	1·0	12	5,000	1·2	1·8	12	75	—
Physically active	3,000	70	1·0	12	5,000	1·5	1·8	15	75	—
With heavy work	4,500	70	1·0	12	5,000	1·8	1·8	18	75	—
Women (weighing 123 lb.)										
Sedentary	2,000	60	1·0	12	5,000	1·0	1·5	10	70	—
Moderately active	2,400	60	1·0	12	5,000	1·2	1·5	12	70	—
Very active	3,000	60	1·0	12	5,000	1·5	1·5	15	70	—
Boys										
13–15 yrs. (103 lb.)	3,200	85	1·4	15	5,000	1·5	2·0	15	90	400
16–20 yrs. (141 lb.)	3,800	100	1·4	15	6,000	1·7	2·5	17	100	400
Girls										
13–15 yrs. (108 lb.)	2,600	80	1·3	15	5,000	1·3	2·0	13	80	400
16–20 yrs. (119 lb.)	2,400	75	1·0	15	5,000	1·2	1·8	12	80	400

amount of information about the energy requirements of work. Much of this is, however, academic and out of date, and hence of limited value to those who have practical tasks of feeding actual workers. For example, it is traditional in the scientific text-books to mention, as an example of an industrial occupation, the energy requirements of a stonemason chiselling a tombstone ![1]

Knowledge of the physical demands of the work carried out in a factory is important for the intelligent designing of the diets of the workers. For example, in one plant "heavy press operation" may be a man's job calling for strenuous physical work, whereas elsewhere a task with the same name

[1] Becker and Hamalainen, 1914, *Skand. Arch. Physiol.*, 31, 198.

may be done almost entirely with automatic mechanical equipment, and perhaps even by a female operative.

The basic requirement of a good diet is that it should provide the amounts of nutrients shown in Table 1. These nutrients, however, must be supplied as food, and the food must be provided as meals. The appropriate number of meals for an individual doing a particular job is a matter of considerable nutritional interest. It is also a subject upon which finality has not been reached. Part of the uncertainty on the subject arises from confused thinking and a lack of accurate observations. For example, it is often assumed that people usually eat three meals a day. This, however, is very rarely so. If a meal is defined in nutritional terms it has to be described in some such words as: " a meal is any occasion during which food providing at least 200 calories is consumed at one sitting ". When this type of definition is applied, we find that some of the working people in Britain and elsewhere eat four meals a day, most of them eat five, and those who have breakfast, a mid-shift snack, dinner, another snack, tea and supper, eat six meals a day. The choice of a dietary pattern appropriate to the type of job a worker is doing always affects his or her contentment and well-being. It may be also important for the maintenance of health, and will certainly affect the efficiency with which the work is done.

Besides the frequency of an industrial worker's daily meals, their timing is also a matter of nutritional significance. Shift work affects the conventional pattern of the daily diet. Even a slight change in the timing of the working hours may profoundly change the type of meal best suited to the men or women concerned, and will in consequence change the type of meal the works canteen should supply if it is to do its job properly. The most extreme example of the influence

of shift times on dietary needs is night-shift working. Night work raises a number of special physiological and nutritional problems which are discussed at length in Chapter Twelve.

Nutritional science provides information about the amounts of the many different nutrients needed for health. Malnutrition occurs when there is a deficiency of a single nutrient or of a group of nutrients. In its more extreme form, malnutrition may show itself as a specific disease—for example, scurvy, or the pellagra of the southern United States, or beri-beri as seen in India, or nutritional anæmia. In its less severe forms it will lead to roughening of the skin, soreness of the tongue, brittle hair, loss of appetite, fissuring of the lips or bleeding gums; and for the industrial worker most forms of malnutrition will be accompanied by a fall in efficiency.

An investigation of the type of diet eaten by a group of people will suggest to an informed observer the nutrients in which it is likely to be deficient, and will therefore also suggest the type of foods which the industrial canteen could most usefully provide in order to make good the deficiency. As a rough-and-ready maxim, it can be said that a nutritionally adequate diet can be constructed from combinations of foods from each of the three groups shown below:

Foods forming a major source of calories.	Foods making major contributions of protein, calcium, iron, etc.	Foods making a major contribution of certain vitamins.
Flour and other cereals. Fat and foods such as bacon, meat, etc., containing fat. Sugar and foods containing sugar. Potatoes.	Milk and milk products. Meat, fish. Eggs. Wheatmeal flour. Beans, peas.	Green vegetables. Potatoes. Fruit.

Nutrition is a quantitative science, and although the table above offers a general guide, it does not provide sufficient information for the sure design of an adequate diet. Furthermore, although a diet composed of black bread and cabbage, in which all three of the above groups are represented, may be nutritionally adequate, it does not conform to the dietary pattern to which many industrial workers are accustomed, and if they were given the opportunity to choose, they would not choose to eat it.

Nutrition is a science, to be sure ; but industrial nutrition, in the sense in which the term is used in this book, is more than a branch of applied biochemistry : it is a social science. Those who are responsible for industrial health must therefore know more than the principles of nutrition. The person in charge of a works canteen has failed if the workers do not choose to eat their dinner there, be its nutritional excellence ever so great. And the reasons which impel a man to avoid the canteen in his factory may be infinitely diverse. He may not wish to pay the price ; he may wish to gamble during the dinner hour ; he may prefer to go home ; he may be doing the shopping for his wife ; he may not like the noise of the wireless ; he may want to walk in the park and smell the flowers ; or he may not like the food. Whatever his reason may be, whether it is financial, æsthetic, social, political or dietetic, if by refusing the meal his daily diet becomes nutritionally insufficient for his needs, then his efficiency as a worker will suffer. In the following chapters the scientific basis of some aspects of the nutritional factor of this complex human problem will be discussed.

Chapter Two

THE NEED FOR CALORIES

THE fundamental attribute of food is to provide the body with energy. When supplies of food are plentiful, interest in the energy value of diets is slight because appetite can usually be relied upon to equate the amount of food eaten to the needs of the body for fuel. When, however, food supplies are scarce, the cardinal importance of an adequate provision of calories becomes immediately obvious.

The basis of the scientific knowledge of the quantitative needs of the human body for fuel was laid in Paris by Lavoisier [1] at the end of the eighteenth century. Although the biochemical processes by which energy is released from food in the body are complex, the end results are that carbohydrate and fat, both of which consist of a chemical framework of carbon, are finally combusted to carbon dioxide and water in a manner closely analogous to the combustion of fuel in mechanical engines. Protein behaves similarly, except that, since the nitrogen which it characteristically contains is not oxidised, only part, and not the whole, of its potential chemical energy is given up.

The Calorie Value of Foods

Foods provide calories [2] in proportion to the amounts of fat, protein and carbohydrate they contain. One gram of

[1] Lavoisier, 1790; see Lusk, "Science of Nutrition", 4th ed. Sanders, London, 1928.

[2] A calorie is a unit of energy. The term as used in nutrition is

carbohydrate or protein produces 4 calories in the body; 1 g. of fat produces 9 calories. Fat is thus the most concentrated source of energy. Water, as has already been mentioned, provides no nourishment to the body, but is rather the medium in which biochemical reactions take place. The calorie value of a food is therefore inversely proportional to its water content. That is to say, the more water a food contains the less calories it provides. A bowl of soup intended for fifty people can be made to serve 100 if water is added to it. But its total food value remains the same, so that the 100, as might be expected, get only half as many calories. The energy values of a number of foods are shown in the list given in Table 2.

From this table the calorie value of a diet can quickly be calculated. For example, a meal of 3 oz. of bread, $\frac{1}{2}$ oz. of butter, 5 oz. of potato, 5 oz. of cabbage, 3 oz. of beef and 1 oz. of cheese will provide

$$3 \times 71 + \tfrac{1}{2} \times 211 + 5 \times 21 + 5 \times 7 + 3 \times 89 + 1 \times 117 = 842 \text{ calories.}$$

The significance of a food in practical dietetics as a source of energy or, for that matter, as a source of nutrients, is not necessarily directly proportional to the number of calories yielded per gram or per ounce. Its value is affected by the amount of it which can conveniently be eaten at a sitting. For example, although milk comes low down on the list, a pint of milk, which is an amount which could easily be drunk at one meal, provides 340 calories. This may exceed the contribution from, say, sugar, which has a higher calorie value per ounce, but of which 3 oz. would be needed to supply an equivalent number of calories.

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strictly the kilo calorie, which is defined as the amount of heat needed to raise the temperature of 1,000 g. of water 1° Centigrade.

TABLE 2

The Calorie Value of Common Foods

(calories per oz.)

Cereals	
Barley	97
Bread, white	73
Bread, national	71
Bread, wholemeal	70
Flour, white	100
Flour, national	97
Flour, wholemeal	95
Oatmeal	111
Rice	99
Dairy produce	
Butter	211
Cheese	117
Egg	45
Egg, dried	163
Milk, fresh	17
Milk, evaporated	40
Milk, condensed	89
Milk, dried, skimmed	97
Milk, dried, whole	138
Fats	
Cooking fat, lard, etc.	253
Margarine	218
Fish	
Cod, white fish, etc.	21
Herring	47
Kipper	62
Salmon, canned	48
Sardine	84
Meat	
Bacon	128
Beef, average	89
Beef, stewing	60
Beef, corned	69
Kidney	36
Liver	40
Mutton, average	94
Pork	116
Veal	31
Legumes	
Bean, baked	25
Bean, haricot	71
Pea, dried	85
Vegetables	
Cabbage	7
Carrot	6
Cauliflower	6
Lettuce	3
Onion	6
Peas, green	17
Potato	21
Spinach	6
Tomato	4
Turnip	5
Watercress	4
Fruit	
Apple	12
Apricot, fresh	7
Apricot, dried	50
Banana	21
Blackcurrant	8
Date	68
Fig, dried	58
Lemon	5
Melon	6
Orange	10
Peach, canned	16
Plum	7
Prune, dried	44
Raisin	67
Miscellaneous	
Beer, mild	10
Chocolate, plain	148
Jam, etc.	71
Peanut	166
Sugar	108

In the country as a whole, in 1945 the total calories were provided in the national diet in the proportions shown from the following sources:

TABLE 3

Proportion of the Total Calories Consumed in Britain Derived from Different Types of Food[1]

	%
Bread and flour	36
Fats	15
Meat	14
Dairy produce	10
Sugar	10
Potatoes	6
All other foods	9
	100

The pioneer research workers in nutrition laid well the foundations of our knowledge about the energy value of foods. These workers, of whom Rubner in Germany and Atwater in America were the greatest, confirmed by repeated experiments the principle first conceived by Lavoisier that carbohydrate and fat produced the same amounts of heat in the body as they did when oxidised in a chemical laboratory. It was thus made possible to assess energy values such as those shown in Table 2 without the need to carry out laborious biological experiments. Recent studies[2] have shown that such laboratory analyses may not always give precisely the true calorific value of a foodstuff, but the numerous detailed tables of food composition now available certainly provide information from which the energy value of any diet can be calculated to a degree of precision which is sufficient at least for most practical purposes. These

[1] "Food Consumption Levels in the U.K.", 1947. Cmd. 7203. H.M.S.O.

[2] Maynard, 1944, *J. Nutrition*, 28, 443.

tables[1, 2] are easily obtained, and anyone who wishes to calculate the composition of a particular diet can refer to them.

The Utilisation of Calories by the Human Body

The basic purpose for which energy is used by the body is to maintain the machinery of life: the circulation of the blood, the beating of the heart, breathing, the resting tension of the muscles and the temperature of the body. This basic expenditure of energy, analogous to the fuel used by a motor car to keep the engine ticking over, is known as the basal metabolic rate or the *basal metabolism*. The basal metabolism of an individual is measured when he is lying still and warm and relaxed and has not had anything to eat for some time. The measurement is usually made before breakfast, when these conditions are most easily fulfilled. Since the energy used to maintain life is derived from the combustion of food previously absorbed into the body, the expenditure of energy needed to keep the body "ticking over" is most conveniently assessed by recording the rate at which oxygen is being absorbed. The oxygen is eventually combined with the carbon and hydrogen, from carbohydrate and fat and protein in the food, and is breathed out as carbon dioxide gas (CO_2) and water (H_2O). When a person breathes into a Roth–Benedict apparatus, the CO_2 is absorbed on soda-lime, and the rate at which the total volume within the machine diminishes is the rate of combustion of oxygen in the body. This is measured on a revolving drum, and from it the basal metabolic rate can be calculated.

The basal metabolism of an individual is proportional to

[1] McCance and Widdowson, "Chemical Composition of Food", 1946, Med. Res. Council, Sp. Rep. Ser. 235, 1946.

[2] "Nutritional Value of Wartime Foods", M.R.C. 1945 War Mem. No. 14.

the amount of living tissue in his body. Thus the calorie consumption of a big man is greater than that of a small one. Similarly, the average needs for basal metabolism of women are less than those of men. The average basal requirement of a man is about 70 calories an hour, equal to 1,680 calories a day, and that of a woman is about 60 calories an hour, or 1,440 calories a day.

These figures can only safely be used as averages for groups, since individuals vary greatly in size. For example, the best measure of the amount of living tissue in the body is provided by the surface area. This is related to height and weight by the formula of Du Bois.[1]

$$S = W^{0.425} \times H^{0.725} \times 0.007184$$

where S is the surface in square metres,
W is the weight in kilograms,
H is height in centimetres.

An " average man " is usually assumed to have a surface area of 1·77 sq. m. The normal rate of basal metabolism for young men is about 40 calories per square metre per hour, although the rate falls slightly as age advances (Table 4). The degree to which the size of an individual affects his basal requirements for calories was strikingly shown by Cathcart and Orr,[2] in their studies of the food requirements of soldiers. Recruits whose average height and weight were 5 feet 8 inches and 131 lb. were calculated to be using 1,542 calories for their basal requirements. If they had been men of the minimum height and physique at that time accepted by the Army, 5 feet 6 inches and 115 lb., their needs would have been 1,400 calories, whereas a group of

[1] Du Bois and Du Bois, 1916, *Arch. Nut. Med.*, 17, 863.
[2] Cathcart and Orr, 1919. " The Energy Expenditure of the Infantry Recruit in Training." H.M.S.O.

public-school youths whose average size was 6 feet and 155 lb. were using 1,700 calories for basal metabolism.

TABLE 4

Normal Basal Metabolism of Men and Women [1]

(Calories per square metre per hour.)

Age—years	Men	Women
14–16	46·0	43·0
16–18	43·0	40·0
18–20	41·0	38·0
20–30	39·5	37·0
30–40	39·5	36·5
40–50	38·5	36·0
50–60	37·5	35·0
60–70	36·5	34·0
70–80	35·5	33·0

The Calorie Demands of Different Types of Work

The first call on the fuel supply of the body derived from the food consumed is therefore for the maintenance of basal metabolism. But every kind of physical activity requires the expenditure of additional calories of energy. The cost to the body of a number of types of muscular exertion has been measured.[2] A number of figures are given in Table 5.

These estimates are values which have been measured by different investigators at different times and with different people as experimental subjects. They obviously must not be taken as absolute and unvarying figures. For example, even though typing is recorded as requiring 16–40 calories per hour and typing quickly as calling for 55 calories per hour, the amount of energy a typist may put into her work may easily

[1] Aub and Du Bois, 1917, *Arch. Nut. Med.*, 19, 823, 840.
[2] Orr and Leitch, 1937–38, *Nutr. Abs. and Rev.*, 7, 509.

TABLE 5

Calorie Requirements for Various Activities

		Calories per hour
Light work	Sitting	15
	Writing	20
	Standing relaxed	20
	Typing	16–40
	Typing quickly	55
	Sewing	30–88
	Dressing and undressing	33
	Drawing	40–50
	Lithographer	40–50
	Violin-playing	46
	Tailoring	50–84
	Washing dishes	59
	Ironing	59
	Bookbinding	43–90
Moderate work	Shoemaking	82–115
	Sweeping	84–110
	Dusting	110
	Washing	124–214
	Charring	81–157
	Metal-working	117–141
	Carpenter	140–180
	House painter	145–160
	Walking	130–240
Hard work	Polishing	174
	Joiner	195
	Blacksmith	276–351
	Rivetting	276
	Marching	280–400
	Cycling	180–600
	Rowing	120–600
	Swimming	200–700
Very hard work	Stonemason	330
	Sawing wood	420
	Coal-mining (average for shift)	320
	Running	800–1,000
	Climbing	400–900
	Walking very fast	565
	Rowing very fast	1,240
	Running very fast	1,242
	Skiing	500–960
	Wrestling	980
	Walking upstairs	1,000

vary still more widely. An important point to observe is that activities involving walking about will almost always fall into the category of hard work, since walking itself is on the border between moderate work and hard work. Similarly, climbing or walking upstairs, even for short periods of time, call for a large expenditure of energy. Although a conductress on a double-decker bus works less hard than a bricklayer's labourer climbing a ladder all day, she is nevertheless engaged on hard work.

Daily Calorie Expenditure of Men in Different Occupations

The total calorie expenditure during the course of a day, which must be balanced by the calorific value of the daily diet consumed, is made up from a summation of each activity of the day. For example, the needs of a tailor can be added up in the following way:

	Calories
24 hours basal metabolism	1,680
1 hour dressing and undressing	33
1 hour walking slowly	115
2 hours light exercise, say	170
4 hours sitting	60
8 hours tailoring at 80 calories/hour	640
	2,698

If we assume that the day's miscellaneous activities of, say, a worker in an engineering plant are the same as those given above for a tailor, but we substitute eight hours of metal-working at 140 calories an hour (*i.e.*, 1,120 calories) for the eight hours of tailoring at 80 calories (*i.e.*, 640 calories), the day's energy output becomes 3,178 calories for engineering work.

The coal-miner's day can be assessed as follows:

	Calories
24 hours basal metabolism	1,680
1 hour walking to and from work	200
8 hours leisure at 40 calories/hr.	320
8 hours work at 320 calories/hr.	2,560
	4,760

Women

The calorie expenditure of women in less than that of men because, as Table 4 shows, their basal metabolism per square metre of body surface is less. Furthermore, body surface itself is related to height and weight, as the formula on page 17 implies, and women, being of smaller average size than men, have lower energy needs for this reason as well. The average calorie expenditure of, for example, a typist and a charwoman are shown below:

Typist	Calories
24 hrs. basal metabolism	1,440
3 hrs. light exercise, say	240
5 hrs. domestic life, say	165
8 hrs. typing at 30 calories/hour	240
	2,085

Charwoman	Calories
24 hrs. basal metabolism	1,440
1 hr. walking	200
2 hrs. sitting	30
5 hrs. domestic life	165
8 hrs. charring at 150 calories/hour	1,200
	2,035

Individual Variability

The figures which have just been given as estimates of the energy demands of different kinds of workers are merely examples. Not only is the requirement affected by the size of the person concerned and by the exact nature of his or her work, but also by the personal individuality of the man or woman under investigation.

Individual variability may be very great. Widdowson,[1]

[1] Widdowson, 1947, *Med. Res. Council*, Sp. Rep. Ser. 257.

for example, found that of twenty young men of eighteen years old whose average food consumption supplied 3,427 calories, the one who ate the least was obtaining 2,338 calories and the one who ate the most 5,221 calories. In spite of these wide variations between individuals, however, it has repeatedly been confirmed that the average requirements for groups of people doing different types of work are remarkably stable. The two most authoritative estimates of the average energy needs for varying degrees of activity are given in Table 6.

TABLE 6

Daily Calorie Requirements of People of Varying Activity

	League of Nations, 1935	National Research Council, U.S.A., 1948.
Adolescents		
Boys 13–15	—	3,200
16–20	—	3,800
Girls 13–15	—	2,600
16–20	—	2,400
Men		
Sedentary	2,400	2,400
Modern work	3,200	3,000
Very hard work	4,800	4,500
Women		
Sedentary	2,400	2,000
Moderate work	3,200	2,400
Very hard work	4,800	3,000

The Relationship between Calorie Intake and Industrial Output

The relationship between the calories in the diet and industrial output is perhaps most clearly shown by the studies of Kraut and Muller,[1] which were made in Germany

[1] Kraut and Muller, 1947, *Science*, 104, 495.

between 1942 and 1945. Twenty men were given a diet providing approximately 2,400 calories daily—that is to say, in addition to their metabolic needs of, say, 1,600 calories they had 800 calories left for work and for their other activities. The men were engaged in building an embankment by shifting earth out of railway trucks. During several months at this work they were able to move 1·5 tons of earth per man per hour. Their rations were then increased to 2,900 calories, and thus provided 1,300 " work " calories additional to the basic 1,600. The output increased in parallel. When difficulties in transport caused the rations to fluctuate, the amount of work done changed accordingly. At the end of a year on the higher level of feeding the men were able to move 2·2 tons of earth per hour, and at the same time their average weight had increased by almost 9 lb. The increase in weight showed that energy resulting from the extra rations had not been expended entirely on physical work. In the next stage of the experiment, therefore, the amount of food supplied to the men remained the same, but they were promised an " inducement " of cigarettes if they increased their production by 15%, to 2·5 tons per hour. After several weeks the reward was given only when 3 tons per hour were achieved ; and later the target was increased to 4 tons. In a short time an output of 3 tons was reached by almost all the men. The final average output was 3·4 tons per man per hour. But during this period, which lasted for six months, a loss of body-weight occurred amounting to an average of 7 lb.

The lesson to be learned from these experiments is clear. The amount of muscular work which a man can achieve depends on the number of calories available from his diet additional to those needed for basal metabolism. If more food, and hence more calories, are consumed, more work can be done. If no more work is done but more food is

eaten, the surplus calorific value can be stored up in the form of muscular tissue or, more commonly, as fat. On the other hand, if a man does more physical work than the calorific content of his diet allows, he must contribute calories from his own body-tissues.

The relationship between the degree of calorie deficiency in the diet and loss in body-weight is a matter of some interest and complexity. The results, in practice, of giving an individual insufficient calories probably occur in the following stages :

First, there is a partly involuntary reduction in physical activity. This reduction affects the output of work as well as the activities of daily life.

Secondly, loss of weight occurs.

The third and final phase sees the development of physical signs of under-nutrition, among which are emaciation, sometimes followed by œdema, which may take the form of the appearance of a swelling of the ankles.

The second phase—loss of weight—does not take place at a uniform rate. It will be remembered that the calories needed for metabolism are proportional to the amount of living tissue in the body : that is to say, to the size of the individual. When a man loses weight, the amount of living tissue in his body becomes less and his total calorie requirements diminish. Ancel Keys [1] and his colleagues at the University of Minnesota carried out an experimental study of under-feeding in which they investigated a group of young men doing fairly hard physical work whose diet was restricted to approximately 1,800 calories daily. Twenty-four per cent of their original body-weight was lost in six months.

[1] Keys *et al.*, quoted by Drummond, *J. Roy. Soc. Arts*, 1946, 94, 470.

From this type of research it can be shown that if a group of people are given a diet only sufficient to provide, say, 90% of the calories they require, 5% of their original body-weight will be lost in three months. For example, if a group of men with an average weight of, say, 154 lb., the requirements of whose occupation are 3,000 calories daily, receive a diet providing only 2,700 calories, they will lose 7·7 lb. in three months. The loss to be expected in six months is, however, only 7% of the original body-weight—that is to say, 10·8 lb. in our example, while the loss in a year will only have increased to 8%, or 12·3 lb., and after this period the body will probably have reached equilibrium.

The practical implications of these facts are important. The ideal physiological weight for an individual is not easy to assess, but it seems clear that as soon as the calorie intake becomes insufficient to support the ideal weight, stage one of under-nutrition occurs, and as weight is gradually lost *a partly involuntary reduction in physical activity* also takes place. In industry, reduced physical activity of this sort almost certainly implies reduced efficiency, but, since after prolonged under-nutrition the body-weight may become stabilised at something less than the ideal weight, the existence of under-nutrition may not be detected.

Canteen meals form the most direct method by which the nutritional value of the diets of people in industry may be influenced. Yet it has been found that in large plants the proportion of workpeople using the canteens may not reach 30%. The motives which impel workers to accept or refuse meals are complex, and include many factors other than the nutritional fitness of the food provided. The predominant need for an adequate calorie intake, which we have just discussed, emphasises the importance of the meals supplied in industrial canteens being sufficiently attractive in whatever

respect attractiveness may lie to ensure that the requirement for calories at least is satisfied.

Experimental Assessment of the Calorie Intake of Workers doing Different Types of Jobs

The calorific needs of different types of industrial work have been assessed in two ways. The first method has consisted of the scientific measurement of the calorie expenditure of each of the separate activities making up the day's work. The figures in Table 5 have been determined in this manner. A second method has been to measure the food consumption of workers engaged in different occupations who have access to an unrestricted diet. This second method cannot claim to represent needs as certainly as can the first, but it has been found in practice to produce figures which are generally in harmony with those determined by the more direct procedure. Some recent results[1] obtained by the latter method during the years 1941–44 are given in Table 7.

TABLE 7

Average Daily Calorie Intake of Certain Groups of Industrial Workers

	Calories.
Sawmill operatives	4,700
Loggers	4,650
Cotton spinners ("male" spinners)	4,050
Steel rollermen	3,750
Coalminers: face workers	3,700
mechanics	3,600
surface workers	3,450
Shipyard workers	3,300
Railway goods handlers	3,300

[1] Pyke, 1947, *J. Amer. Dietectic Assn.*, 23, 90.

Lusk[1] estimated the average daily requirements of a number of different occupations from direct physiological data, and then demonstrated the influence of body-size (height and weight) in the same way as Cathcart and Orr had done for soldiers. For example, a carpenter 5 feet 8 inches tall and weighing 155 lb. needed 3,200 calories daily. For the same job a man 5 feet tall weighing 128 lb. required 2,900 calories, while one 6 feet 2 inches tall weighing 189 lb. required 3,500 calories.

The Mechanical Efficiency of the Human Body as a Work Engine

The efficiency of the human body as a producer of mechanical work is low. It is not dissimilar to that of the steam locomotive or the internal-combustion engine. It has been found in experiments with men riding fixed bicycles that for each 100 calories of energy consumed from food, only 10 to 25 calories are produced as mechanical work. This subject is discussed again in Chapter Ten. In this context a calorie, which is in terms of heat, is equivalent to approximately 3,086 foot-pounds when expressed as work. The efficiency of the human body as a machine therefore varies from 10% to 25%, depending on the type of work, the speed with which it is done and the skill and training of the individual doing it. Orr and Leitch[2] calculated that for sustained work the maximum human efficiency to be expected is about 18%.

The mechanical efficiency of muscular work is markedly affected by training. Improvements as great as 37% are quoted in the scientific literature. But of equal interest to the industrialist is the way in which the worker is enabled

[1] Lusk, 1928, " Science of Nutrition ", 4th ed. Saunders, London.
[2] Orr and Leitch, 1937–38, *Nutr. Abs. and Rev.*, 7, 509.

to apply his strength to the job. For example, Atzler[1] measured the energy requirement of a man lifting weights of various heaviness from the ground and from varying distances above the ground. The results have been recalculated, and are summarised in Table 8.

TABLE 8

Calories Required to Lift 1 lb. 1 ft. from the Floor or from Given Heights from the Floor to Different Measured Levels

Original height, ins.	Height lifted, ins.	Weight lifted. Calories per 1,000 ft./lb. of work.		
		20 lb.	30 lb.	63 lb.
0	20	10·6	8·1	6·0
	40	8·3	6·6	5·9
	60	6·8	5·5	5·6
	80	6·1	5·2	5·7
20	20	7·1	6·0	5·8
	40	5·4	4·7	5·4
	60	5·1	4·5	5·4
40	20	4·5	4·1	5·7
	40	4·5	4·1	5·0
60	20	5·4	4·6	7·1

It can be seen from this table that it is easiest and most economical to lift a weight from a position, say, 40 inches high rather than to lean down, pick it up and raise it through the same distance from the ground. Thus, to raise a ball weighing 30 lb. from the ground to a height of 40 inches calls for the expenditure of 0·0066 calorie per foot-pound of work done, whereas to raise it from a table 40 inches high to a shelf 80 inches high requires only 0·0041 calorie per foot-pound. This is a saving of 38% of the

[1] Atzler, 1924, *Technik and Wirtschaft*, No. 8, 173, quoted by Lusk, 1928, " Science of Nutrition ".

workman's energy per unit of work done. The same principle applies to other types of work—for example, the turning of a crank fixed at varying levels above the ground. The most efficient height for the crank is the height of the man's navel. The efficiency of work on a stationary bicycle is similarly greatest at certain speeds, which differ with different individuals.

Conclusions

A general understanding of the needs of men and women for calories for the performance of the different daily tasks they may be called upon to do, and of the differing amounts of calories supplied by the several types of food, is essential for anyone concerned with industrial nutrition. Whether or not he is to do his daily work, a man must burn up 1,600 to 1,800 calories to keep himself going—that is to say, for basal metabolism. If the additional 1,400 to 1,900 work calories are not available, he cannot do his work properly and, looking at the problem from the purely materialist point of view, the major part of the industrial investment in the man is thereby lost.

The calorie expenditure that a man or woman is called upon to make in doing work depends on the muscular energy required to perform the job. In this respect again the problem may be considered on a materialistic or mechanical basis. Like a mechanical engine, the human body is not particularly efficient. Only about 18% of the energy of the diet can be expected to be returned as mechanical work. But again, like an engine, a man can work more effectively if his task is organised to suit him. Ten foot-pounds are needed to lift 10 lb. 1 foot; but this work, as we have seen, can be achieved with a greater economy of calories when a man is enabled to lift the 10 lb. from a table of a

height that suits him on to a shelf 1 foot above it, than when he must pick up the weight from the floor and put it on a bench 1 foot high. Economy of calorific expenditure can be achieved by arranging for workers to "get at" their work in this way in almost every type of industry. We must consider this problem again when discussing coal-miners in Chapter Ten and outdoor workers in Chapter Eleven.

If body-weight is to be maintained and the physical structure thus kept in repair as an effective engine for the performance of work, enough calories must be consumed; and these calories can only be derived from the diet. A man can fall back for a time on the tissues of his own body and, as the saying is, "work his fingers to the bone", but he cannot go on doing this for long. An underfed workman is an inefficient workman. Foods provide different amounts of calories. Ounce for ounce, fats; foods containing fats, such as ham; sugar; and all cereals and foods such as bread made from cereals are concentrated sources of calories. Fruit, green vegetables, turnips and such like and other watery foods are poor sources of calories.

But these facts must be used with intelligence. Bread, it is true, provides 71 calories per ounce, and eggs only 45. Yet by giving a man an egg for his tea he will get the calories it supplies and also those from the bread he rubs round his plate to mop up the yolk with. In short, an industrial worker is *more* than the mechanical engine to which we have compared him, and his nutrition depends on more than the scientific principles governing the energy output of his muscular tissues.

We must indeed provide him, our fellow man, with the calories he needs according to his physiological requirements; but we must do so in the form of meals which he will be glad to eat.

Chapter Three

THE SIGNIFICANCE OF FAT

FAT is the most concentrated source of calories, and is, in consequence, of particular significance in the nutrition of industrial workers who are called upon to exert much physical energy in their daily occupations. There is no precise physiological requirement for fat as such; but its high energy value, its palatability and its usefulness as a culinary ingredient render it of great importance in practical dietetics. For example, not only is a slice of bread-and-butter pleasanter to eat than a slice of dry bread, but its calorific value when it is buttered in a normal way is about 30% greater.

The proportion of fat which people eat is markedly influenced by custom. Before we discuss the significance of fat in the diet of industrial workers in the United Kingdom, it is worth reviewing the consumption of fat in different parts of the world.

Fat in diets can be considered as being of two kinds: "visible" fat—that is to say, fats such as butter, margarine, lard or cooking oil, which are added to the diet in a recognisable and measurable form—and the "invisible" fat which is contributed by meat, fish, cheese and other foods. The sources of the total "visible" and "invisible"

fat in the British diet in 1945 are shown in the figures below:[1]

TABLE 9

The Sources of Fat in the British Diet

	%
Fats (butter, margarine, fats, etc.)	40
Meat (including bacon)	32
Dairy produce (excluding butter and eggs)	16
Cereals (bread, flour, etc.)	6
Eggs	2
Other foods	4
	100

The average fat supply in 1947 amounted to 111 g. per head per day and provided 35% of the nation's total calories. This compared with 39% in 1938. In a number of countries the national diet contains more fat than this. For example, Eskimos have been found to derive 46–51% of their calories from fat,[2] and in Finland[3] and Holland[4] groups of people have been studied whose fat consumption supplied more than 40% of their calories.

There are, on the other hand, groups of people in other countries who eat less fat than we do. Heavy workers and others in Japan, where rice is the staple food, have been found[5] to obtain only 6% or 7% of their daily calories from fat. In Italy[6] and in Roumania[7] it has been calculated

[1] Derived from "Food Consumption Levels in the United Kingdom", 1947. Cmd. 7203. H.M.S.O.

[2] Rabinowitch, 1936, *Canad. Med. Ass. J.*, 34, 487.

[3] Sundstrom, 1917, *Skand. Arch. Physiol.*, 19, 78.

[4] Banning, 1929–30, "De voednig to Zaandam in 1929–30". Zaandam.

[5] Oshima, 1905, U.S. Dept. Ag., Bul. 159.

[6] Bottazzi, 1935, *Nutr. Abs. and Rev.*, 5, 275.

[7] Aykroyd, Alexa and Nitzalescu, 1935, *Arch. Path. Exp. Microbiol.*, 8, 407.

that peasants, while better off than the Japanese in this respect, eat diets in which fat is responsible for a mere 16% or 17% of the day's calories.

Fat is usually considered to be a desirable component of the diet. For example, Sir John Orr in his dietary surveys of 1936[1] found that the poorest families in the country derived 28% of their calories from fat, whereas the richest ate 38% of fat-calories. And in a separate survey, Widdowson and McCance[2] found that 42% of the calories consumed by a group of middle-class women was derived from fat. These people came from a social grade above the average, and their fat consumption was also higher than the average.

How Much Fat do People Require ?

One of the first modern estimates of the amount of fat required in a nutritionally adequate diet was made by the British Medical Association in 1933.[3] The B.M.A. Committee on Nutrition at that time recommended that a diet should contain 100 g. of fat. Since 1 g. of fat produces 9 calories, this 100 g. (approximately $3\frac{1}{2}$ oz.) would supply 900 calories, or 30% of a 3,000-calorie diet.

An energy value of 9 calories per gram of fat, or 253 calories per ounce, represents the highest concentration of energy possible in any type of food. For this reason, when the total daily energy expenditure is great—that is to say, when a man is working hard—it is a convenience to him, and in some circumstances a necessity, to eat an increased amount of fat, in order that his diet may remain reasonably compact.

With this object in mind, the Food and Nutrition Board

[1] Orr, *Food, Health and Income*, Macmillan, London, 1936.
[2] Widdowson and McCance, 1936, *J. Hyg.*, 36, 293.
[3] British Medical Assn. Rep. Cttee. on Nutr. 1933.

of the U.S. National Research Council[1] recommended the following :

Total daily energy requirement.	Proportion of total calories to be derived from fat, %.
Less than 3,000 calories	20–25
More than 3,000 calories	30–35

These recommendations can only be used as a guide, but they do emphasise the essential point, which is that the requirement for fat increases as the total energy expenditure increases. In practice, more fat than this is needed to keep industrial workers satisfied in the Western world, whether or not the U.S. recommendation is sufficient for their physiological needs.

It is interesting to refer back to Table 7, containing the records of the diets of industrial workers studied during World War II. The loggers who were then estimated to be eating a diet providing 4,650 calories daily, were calculated to be obtaining 37% of their calories from fat, whereas the surface mine-workers, with a total intake of 3,450 calories, got only 26% of them from fat. Although the figures fluctuated among some of the other intermediate groups studied, there was a clear trend of a falling proportion of fat-calories in parallel with a lowered total energy consumption.

Dietary Sources of Fat Calories

It has already been stated that 40% of the total fat in the British diet is derived from " visible " fat—that is, from fats themselves. Of these, cooking fats and oils are composed entirely of fat. That is to say, each ounce (28 g.) of lard or

[1] U.S. Nat. Res. Council, 1945, Bul. 122, Wash.

cooking-fat or frying-oil provides 28 × 9—*i.e.*, 252 calories. Butter and margarine are fats intermingled with approximately 14% of water, and hence provide only 211 and 218 calories per ounce respectively. Fats and oils are similar in chemical composition, and are practically identical as sources of energy in the body.

Meat as a Source of Fat

Whereas 40% of the dietary fat is derived from fats eaten as such, 32% is provided by meat. It is this fact which unconsciously and in part underlies the preference which many workers have for meals containing large amounts of meat. Different types of meat vary widely in the amount of fat which they contain, and hence in the concentration of calories they bring to the diet. For example, bacon "fat-backs" consist of 85% of fat, and hence provide 221 calories per ounce—an energy value greater than that of butter. American fat bacon contains 70% of fat. The more customary types of bacon contain from 28% to 61% of fat; average pre-1939 Wiltshire bacon contained 37·4% of fat and provided 112 calories per ounce. The edible part of a grilled pork chop contains 50% of fat.

The variation in the fat content of beef and mutton is as great as that in pork and bacon. Frozen beef contains 7·3% fat, stewed steak 8·6%, corned beef 15·0%, boiled silverside 20·0%, grilled steak 21·6%, roast topside 23·8% and roast sirloin 32·1%. The consequent calorie concentration ranges from 42 to 106 per ounce. The composition of mutton is equally diverse. For example, boiled leg of mutton contains 16·6% of fat, stewed scrag and neck 24·4%, while the edible part of a grilled chop contains 45·0% of fat.

The outstandingly high fat content of certain types of

bacon explains the reason for the popularity of fat bacon or of bacon, and ham-sandwiches among heavy workers. These foods provide in a conveniently compact form the large number of calories needed for the execution of substantial muscular effort.

Milk as a Source of Fat

Milk is an astonishing food. Its value for children need not detain us here. But it can also be a useful item in a worker's diet. An average sample of milk will contain 3·5% of fat; but whereas a man might consider as a fair helping, say, 4 oz. of stewed steak containing 8·6% of fat—that is to say, a weight of 9·6 g. of fat—he will, when it is available, drink for incidental refreshment a pint of milk. A pint is 20 oz., and will provide 19·6 g. of fat. It is therefore not surprising that dairy products other than eggs and butter contribute 16% of the national fat supply.

The Significance of Fat in Reducing the Bulk of the Heavy Worker's Diet

The problem of feeding men for the production of work is basically similar to the problem of feeding horses. If a man has to do work calling for a substantial amount of energy, he can most conveniently obtain the calories he needs if his diet is provided in a concentrated form. This implies that the amount of fat in it is sufficient to provide a proportion of the total calories ranging from, say, 35% to 40% of the whole. Similarly, a horse can subsist comfortably on grass, which is a bulky feed in proportion to the calories it provides, so long as it is not asked to do hard work. When it is working hard, it must receive some more concentrated ration, such as oats.

The factor of the bulkiness of the diet brings us to the important question of the choice between hot cooked meals and so-called snacks. A hot meal comprising a 2-oz. slice of meat with gravy, 4 oz. of potatoes, 4 oz. of cabbage, 4 oz. of steamed pudding and custard will weigh 17 oz., will contain 7% of fat and will provide 620 calories. Yet a 6-oz. meat pie from a snack bar will provide the identical calorie value with little more than one-third of the bulk. Similarly, a good ham-sandwich made up of 2 oz. of ham, 5 oz. of bread and ½ oz. of butter will supply 710 calories for a total weight of 7½ oz. A hot meal possesses many important nutritional attributes not found in the ordinary snack. Among these are vitamin C, vitamin A and other nutrients. Yet, to our industrial worker at his job, calories are the primary consideration, and it is often for this reason that he chooses a " snack ".

The working horse cannot store enough grass in its stomach to provide the energy to keep it going. To continue working it must stop and eat again. A working man will complain that a bulky meal in the middle of his shift does not " stay with him ". Furthermore, the bulk of a meal of low fat concentration, which is consequently of low calorie concentration, may of itself be an obstacle to the efficiency of a man such as a miner, who does heavy labour in a crouching position.

Satiety Value

We now see that the primary function of fat is the provision of calories in concentrated form. A second subsidiary consideration is " satiety value ". Fat delays the passage of food through the stomach. It thus gives a more prolonged feeling of satisfaction than other nutrients.

Some Examples of the Practical Effect of Fat on Nutritional Values

We are here considering calories only. The design of a balanced diet will be discussed later. As a concentrated source of calories, bread-and-dripping or, for that matter, bread-and-butter rank high. Biscuit, which is a drier form of baked cereal product, has in consequence an even higher calorie content per ounce than bread. Another mixture of carbohydrate with fat, which is in consequence of high calorie value, is cake. The influence of fat in increasing the calories to be derived from foods of this kind can be seen from the following figures:

TABLE 10

The Effect of Fat on the Calorie Value of Cereal Foods

	Fat content, %.	Calories per oz.
Bread	1	72
Bread and butter	11	93
Cake	14	110
Bread and dripping	20	123
Biscuit, "water"	12	131
Biscuit, "digestive"	20	143
Pastry	30	152

It can easily be understood from these figures why buns and cake and bread-and-dripping are popular with many workers. They are "unbalanced" foods, but they supply calories. Pastry is of particular interest, since it forms a major constituent of Cornish pasty, meat pie, sausage roll and of numerous local combinations—for example, meat-and-potato pie. Through its presence the calorie value of sausage or mincemeat—foods which, though savoury in flavour, are not of concentrated energy value—is increased to a marked

degree. On one occasion it was found that a canteen manageress who was apologetic about the " unsubstantial " meal of Cornish pasty, which was all she had been able to provide for a night shift, was in fact supplying slightly more than 1,000 calories in that one item alone.

The Effect of Frying

A similar increase in the calorie concentration of foods is brought about by frying. The process is again the admixture of fat combined with loss of moisture. Some figures demonstrating this effect are given in the following table.

TABLE 11

The Effect of Fat Used in Frying on the Calorie Value of Foods

	Fat content, %.	Calories per oz.
Potatoes, boiled	Nil	21
Potatoes, fried (chips)	9	66
Cod, boiled	1	23
Cod, fried	4	40
Onions, raw	Nil	7
Onions, fried	33	102

Practical Applications of the Properties of Fat in Communal Feeding

Unconsidered snacks and the so-called " subsidiary " meals are often, at least so far as calories are concerned, of greater significance than many cooked meals. The latter play an important part in the provision of a balanced, healthy diet, but the minor meals cannot for that reason be overlooked. In 1926 Professor Schiotz in Oslo devised what later became known as the " Oslo breakfast ". This was a meal for schoolchildren designed to provide " protective "

foods containing vitamins and other nutrients in which it was thought that the home diet of the children was likely to be deficient. Underlying the idea of the " Oslo breakfast " was the premise that the children were obtaining enough calories in their diet from such foods as bread-and-jam given them by their parents. Although this principle was adopted in other countries as well as Norway, it has, since 1941, been necessary to modify the basic design of school meals for children in Britain. Besides providing vitamins, minerals and proteins, the school meal must now also supply as its essential quality a substantial minimum contribution of calories.[1]

This modified principle must also guide industrial nutritionists. Although many complex factors may influence the nutritional requirement arising from the special and varied conditions of industrial life, fundamentally the problem is one of energetics ; a man must consume enough calories for the mechanical work he is called upon to do. At some stage in the day's diet, vitamins and other factors must be provided; but it is only appropriate to concentrate exclusively on these nutrients when the calorie requirement has first been met.

The competition between vitamins and calories may take a form such as this. The mashing of potatoes gives rise to a loss of vitamin C. The more efficiently and " smoothly " the potatoes are mashed the more vitamin is lost. It might therefore be thought that the nutritive value of the diet for a group of workpeople would be improved if the mashing of the potatoes provided for them were forbidden. In practice, however, two considerations arise. First, mashed potatoes are usually popular, and their prohibition may lead to the consumption of less rather than more vitamin C if the

[1] Board of Education Circulars No. 1571, Nov. 12th, 1941 ; No. 1584, Feb. 24th, 1942.

workers eat less unmashed potatoes. Secondly, fat can be conveniently mixed with potatoes while they are being mashed, and the calorie value of the diet thereby increased. A moderate deficiency of calories will do more immediate harm to working efficiency than a moderate shortage of vitamin C.

Unexpected Fat-containing Sources of Calories

The presence of fat may often imply that a meal or snack which appears to the eater to be hardly worthy of mention is

TABLE 12

The Fat Content of some Common Foods

(Grams per oz.: average values.)

Cereals		*Fish* (cont.)	
Barley	0·5	Kipper	4·5
Bread, white	0·2	Salmon (canned)	2·8
Bread, national	0·3	Sardine	6·8
Bread, wholemeal	0·6		
Flour, white	0·3	*Meat*	
Flour, national	0·4	Bacon	12·8
Flour, wholemeal	0·9	Beef, average	8·0
Oatmeal	2·5	Beef, corned	4·5
Rice	0·3	Kidney	2·0
		Liver	1·7
Dairy produce		Mutton	8·8
Butter	23·4	Pork	11·4
Cheese, Cheddar	9·8	Veal	1·0
Cream	11·9		
Egg	3·3	*Vegetables*	
Egg, dried	11·9	Green vegetable, Legumes, pea, Legumes, bean, Potato, Root vegetable	Nil
Milk	1·0	Soya bean	4·3
Milk, evaporated	2·3		
Milk, condensed	2·6	*Fruit*	
Milk, dried, skimmed	0·2	All sorts	Nil
Milk, dried, whole	7·6		
		Miscellaneous	
Fats		Peanut	2·2
Cooking fat, lard, oil	28·1	Chocolate, plain	9·2
Margarine	24·1		
Fish			
Cod, white fish	0·3		
Herring	3·3		

in fact a substantial contribution to the day's needs. Bread-and-dripping has already been discussed. Ice-cream, another example, may contain 15% of fat and can provide more than 200 calories in a serving of 3 oz. Mayonnaise, if it can be well made, will contain 78% of fat; if it does, two spoonfuls—say between 1½ and 2 oz.—will provide 350 calories. When foods such as these are freely eaten the fat content of the diet will be high and the calorie value of the meal containing them will be high also. Table 12 gives the fat content of a number of different types of everyday foodstuffs. The figures are average values; we have already seen, in our discussion of different types of meat, that individual specimens of food may deviate widely from these averages.

Sugar Compared with Fat as a Source of Calories

Sugar is a substance which possesses the property primarily possessed by fat of raising the concentration of calories in foods without increasing their bulk. This property in fats is derived from the fuel value of fats themselves. Sugar, in the form in which it is commonly handled, is solely carbohydrate, and thus provides approximately 4 calories per gram—*i.e.* 108 calories per ounce. This value is similar to that of other carbohydrate foods which are also met with comparatively free from moisture. Flour, for example, provides 98 calories per ounce. Sugar, however, is very soluble in water, and it can therefore be added to foods without increasing their bulk. Its addition, in consequence, raises the *concentration* of calories.

A dish, such as apple pie, is no more bulky if in each piece a tablespoonful of sugar—say, 20 g.—has been mixed with the apples. The sugar will, nevertheless, have added 80

calories. Similarly, a cake may contain in the same bulk much or little sugar.

Conclusion

Edible fats and oils are chemically composed of one or other of a number of fatty acids linked in threes to glycerol. The combination of fatty acids in the linkage decides whether the fat will have a comparatively high melting point, like lard, or a low one, like olive oil ; whether when it deteriorates it will have a smell like that of rancid butter, which is due to the presence of the fatty acid *butyric acid*, or whether it will smell of goat, the fat of which is rich in *capric acid*. Nutritionally, fats are of closely similar value, if we restrict ourselves to the behaviour of the fats themselves, and reserve for discussion later the vitamins which may be associated with them. Part of the quality of fats depends on the fatty acid–glycerol linkage. This is broken during digestion. Mineral oils which can be used, albeit improperly, in cooking are of different chemical structure, and cannot be broken up as can edible oils during digestion. They have in consequence no nutritional value, and may in fact exert nutritionally harmful effects by dissolving vitamin A from other foods and causing it to be lost from the body. The consumption of excessive amounts of mineral oil may also damage the liver.

Fats are nutritionally valuable as the most concentrated source of calories. They are therefore of particular significance in the diet of heavy workers, who must consume large amounts of calories, and who may need to do so without having to eat a large bulk of food. Men have been shown to be able to live and work when 15% or less of their calories comes from fat. Certain of the fatty acids composing fats are essential to the health of the skin and other tissues, but the minimum amount of fat needed to meet the biological

needs for health of *homo sapiens* is less than the amount upon which a workman can, under Western industrial conditions, do work at maximum efficiency. For men whose daily energy expenditure is, say, over 3,500 calories, it is probably desirable to provide 40% or more of the calories as fat—*i.e.* 140 g. daily. Less active workers can obtain their dietary requirements with a lower consumption of fat, or, say, 30% of a total intake of 3,000 calories—*i.e.* 100 g. of fat.

The beneficial effects of fat on a diet for heavy industrial workers, which include the limitation of excessive bulk, an increase in palatability and improved " satiety value ", cannot be increased indefinitely by continuously raising the fat content. In order to make use of fat the body needs carbohydrate, or certain constituents of protein, which yield carbohydrate during their utilisation. When the proportion of fat in the diet rises above the level at which more than two molecules of fatty acid are present for each molecule of the carbohydrate, glucose or its equivalent, acidosis occurs. Individuals can become accustomed to high concentrations of fat in their diet, but, in general, when 50% of the total calories come from fat the maximum level has been reached.[1]

In short, what the student of industrial nutrition must remember about fat is :

(*a*) Fat is useful in the diets of industrial workers because they like it.

(*b*) It is valuable for heavy workers because it is the most concentrated source of calories, and hence enables a substantial energy value to be eaten without excessive bulk.

(*c*) It has a high " satiety value ". It delays the rapid passage of food from the stomach, and thus postpones

[1] Keys, 1943, *Federation Proc.*, 2, 164.

the hunger of those workers who are unable to enjoy frequent snacks.

(*d*) Its presence in cakes, pastry, pies, ham-sandwiches and bread-and-dripping often enables such "minor" articles of diet to supply more fuel than does a full-dress meal.

As a postscript, let us remember that it is the beef fat—call it suet if we must—that is the principal reason for the fixed belief of so many workmen that suet pudding is the only real pudding.

Chapter Four

PROTEIN, MEAT AND WORK

EVERY schoolboy now knows that meat is a "protein food". When he grows up, however, and becomes a working man, he finds that it is a good deal more. In this chapter we shall discuss the function of protein in the nutrition of the industrial worker and the peculiar claim possessed by meat, and not only on account of its protein content, to fill a place in his diet.

Carbohydrates and fats are composed of carbon, hydrogen and oxygen. In the body they become broken down by a complex continuous process of oxidation until as carbon dioxide (CO_2) and water (H_2O) they are finally excreted in breath. From this chain of chemical reactions the energy for daily life is fundamentally derived. As has already been stated, 1 g. of fat provides 9 calories of energy and 1 g. of carbohydrate provides 4 calories.

Protein, like carbohydrate, also provides the body with 4 calories per gram; but, unlike either carbohydrate or fat, protein has a special nutritional function. It is composed of *amino-acids*, which are needed for the growth and repair of muscular and other tissues. These amino-acids all contain nitrogen.

Dietary Sources of Protein

The protein content of a number of common foods is shown in Table 13.

TABLE 13

The Protein Content of Certain Foods

(Grams per oz. of edible portion.)

Meat		*Fats*	
Bacon	3·1	Cooking fat, Margarine, Oil	Nil
Beef, average	4·2		
Beef, stewing	4·1		
Beef, corned	7·1		
Kidney	4·5	*Miscellaneous*	
Liver	4·8	Sugar	Nil
Mutton	3·7	Jam	0·1
Pork	3·4	Chocolate	1·3
Veal	5·3		
		Fruit	
Fish		Apple	0·1
Cod, etc.	4·5	Apricot	0·2
Herring	4·5	Banana	0·3
Kipper	5·4	Date	0·6
Salmon	5·7	Orange	0·2
Sardine	5·7	Pear	0·1
		Plum	0·2
		Prune, dried	0·7
Dairy produce			
Butter	0·1	*Vegetables*	
Cheese	7·1	Cabbage	0·4
Egg, fresh	3·5	Carrot	0·2
Egg, dried	13·0	Cauliflower	0·7
Milk, fresh	0·9	Lettuce	0·3
Milk, evaporated	2·0	Onion	0·3
Milk, condensed	2·3	Pea, green	1·6
Milk, dried, whole	7·3	Potato	0·6
Milk, dried, skimmed	10·2	Spinach	0·8
		Tomato	0·3
		Turnip	0·2
Cereals		Watercress	0·8
Barley	2·2		
Bread, white	2·3	*Pulses*	
Bread, national	2·4	Bean, haricot	6·1
Bread, wholemeal	3·1	Pea, dried	7·0
Flour, white	3·1	Lentil	6·8
Flour, national	3·3		
Flour, wholemeal	3·9	*Nuts*	
Oatmeal	3·4	Coconut	1·1
Rice	1·8	Peanut	8·0

In assessing the significance of the above figures we must, as before, jointly with the amount of protein per ounce in a particular food, also remember the amount of the food in

question commonly eaten. To do this it is interesting to observe the foods from which the total British protein consumption is derived. The proportions of the national protein consumption in 1947 are shown below.[1]

TABLE 14

The Proportions of the Total National Protein Consumption Derived from Different Foods

	%
Bread, flour, etc.	40
Dairy produce	20
Meat	17
Fish, poultry	6
Potatoes	6
Eggs	4
Other foods	7

Proteins, as we have already said, are peculiar because in their component amino-acid they possess "amino-groups," containing nitrogen. The amount of protein ingested in the diet can most conveniently be assessed by measuring the amount of nitrogen. The protein used by the body either as a source of energy or through the wear and tear of muscular tissue can be assessed by analysis of the urine and fæces excreted. If the amount of nitrogen consumed is equal to the amount excreted, the body is said to be in nitrogen balance. If more nitrogen is lost than is consumed, the body is said to be in "negative" balance and the protein consumption considered to be insufficient for adequate nutrition. If more nitrogen is ingested than is lost, the balance is said to be "positive". Growing children, for example, must be in "positive" balance.

[1] "Food Consumption Levels in the United Kingdom", Cmd. 7203, H.M.S.O.

Although meat is a food of great dietetic attractiveness to most industrial workers it cannot claim to possess special nutritional significance for them. There are, for example, many vegetarian races who maintain themselves without meat. The significance of meat as a source of fat has already been discussed, and the iron and vitamin content of meat will be referred to in later chapters. It is the importance or otherwise of meat as a source of animal protein which it is now proposed to consider.

The Biological Value of Proteins

The nutritional value of different proteins depends on the combination of amino-acids of which they are composed. The " biological value " of proteins can be measured by the degree to which they permit growth in experimental animals. The proteins of milk are of highest " biological value ", but they are closely followed by proteins from other animal foods, and it is often stated for brevity that all animal proteins as a group are of high " biological value " or are " first-class " proteins, whereas vegetable proteins are " second class ". There are certain exceptions to this general proposition. For example, gelatine is an animal protein, but is of low " biological value " because the amino-acid, tryptophane, is lacking in it.

The explanation of the general rule, that animal proteins are of higher " biological value " than vegetable proteins, is as follows. Human protein is a mosaic of amino-acids which combine to give it its special characteristics. The protein of meat, of which the muscular tissue of an ox or a sheep is composed, is not greatly different. The mosaic of beef-muscle must be broken down in the human system, but the amount of rearrangement of amino-acids needed to con-

struct human muscle from it is not very much. On the other hand, the amino-acid composition of wheat protein is substantially different from that of human protein. The order of magnitude of these differences is shown in Table 15.

TABLE 15

Approximate Percentage of Amino-acids in Meat Protein and in the Protein of Flour

Amino-acid.	Meat.	Flour.
Arginine	7·2	3·9
Histidine	2·1	2·2
Lysine	7·6	1·9
Tyrosine	3·1	3·8
Tryptophane	1·2	0·8
Phenylalanine	4·5	5·5
Cystine	1·1	1·9
Methionine	3·2	3·0
Threonine	5·3	2·7
Leucine	12·1	12·0
Isoleucine	3·4	3·7
Valine	3·4	3·4
Glutamic acid	15·0	2·5
Glycine	4·0	7·2
Proline	6·0	10·0

The difference between the nutritional quality of different proteins is most significant for children and adolescents who are growing. For adults it has repeatedly been shown that a mixed diet providing proteins from different sources—for example, from cereals and from leafy vegetables, or from vegetable and animal foods combined—enables the body to utilise the protein mixture as economically as if it were wholly derived from animal sources. Macrae[1] during the war demonstrated this phenomenon with the mixed proteins of diets provided for airmen in the R.A.F. Hence, in dis-

[1] Macrae, *et al.*, *Biochem. J.*, 38, 132.

cussing the influence of protein on the muscular efficiency of industrial work, it is difficult to find evidence to justify the singling out of meat as a source of protein. Be that as it may, let us now discuss the significance of protein as such for the performance of physical work.

Protein and Muscular Work

The weight of scientific evidence shows clearly that the minimum protein intake necessary to maintain nitrogen equilibrium is about 50 g. daily. In recent years it has been the fashion to add 50% to this figure as a safety margin, although there is little scientific justification for this practice, and to set the "requirement" of protein at 70 g. daily for a man.[1] This can perhaps be expressed better as 1 g. of protein per kilo of body-weight (1 kg. = 2·2 lb.). Although frequent statements are to be found that higher intakes are necessary for hard work, very few of these have any experimental basis. Indeed, extensive experimental work carried out by Chittenden[2] in 1904 showed that increased vigour was achieved for hard-working men when pains were taken to restrict the protein intake to from 50 to 60 g., which is a lower level than is commonly found for any normal diet supplying the calories eaten by heavy workers.

Chittenden's results of 1904, which indicated that no impairment of vigour occurred when dietary protein was restricted, were confirmed by a study carried out at the Harvard Fatigue Laboratory[3] in 1944. Twenty-four fit young men were investigated over a period of twelve weeks. Throughout

[1] L. of N. 1936, *Quart. Bul. Health*, Aug. 5, 391; U.S. National Research Council, 1945, Bul. No. 115.

[2] Chittenden, 1904, "Physiological Economy in Nutrition". New York.

[3] Darling, R. C., Johnson, R. E., Pitts, G. C., Consolazio, F. C., and Robinson, P. F., 1944, *J. Nutrition*, 28, 273.

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the test they continued with their normal activities, which ranged from lorry-driving, road-mending, forestry and carpentry, to office work and work in the kitchen or laundry. After a period of two weeks on their normal diet, one group of men was given a low-protein ration, a second group received a high-protein diet and the third group continued as before. The men were allowed to eat as much as they liked in order to satisfy their calorific needs. The average calories consumed by the three groups during the experimental period of eight weeks were 3,350, 3,740 and 3,120 for the low-protein, high-protein and normal groups respectively. The average protein consumption was 53 g. for the " low-protein " group, 168 g. for the " high-protein " group, and 105 g. for those who were eating their normal diet. These figures suggest that they were all getting enough to eat.

As a measure of his degree of fitness, each man was subjected periodically to a rigorous " pack test ". In this test the man, wearing a rucksack weighted to one-third of his body-weight, stepped on to a 16-inch platform and down on to the floor again once each two seconds. Handrails at shoulder height were provided as an aid. The exercise was stopped after five minutes if the man was able to continue for that length of time, and his pulse was counted for three periods: one to one and a half minutes, two to two and a half minutes and four to four and a half minutes after the completion of the test. A numerical measure of fitness had previously been worked out based on the records of pulse rate and time. This test of fitness is known not to be perfect, but it is at least a rough measure of ability to stand up to heavy exercise.

The results of the experiment showed that there was no significant difference between the physical fitness of the three groups. That is to say, the men were just as fit and

did their work just as well whether they ate a lot of protein, a little protein or a normal amount.

Much of the protein consumed by an adult is used for the production of energy, but there is no reason to believe that protein is the primary fuel for physical work ; on the contrary, the fundamental fuel for muscular activity is known to be glucose which is derived from carbohydrate which is provided by such foods as bread, sugar or potatoes.

Muscular work is followed by a very slight increase in the amount of nitrogen excreted from the body. This was thought by Cathcart [1] to imply that protein was being used specifically by the muscles. The additional loss of nitrogen continues for twenty-four to thirty-six hours after exercise, but it is not proportional in amount to the amount of work done, and after three days the amount of nitrogen excreted falls below the basal level.[2] These facts certainly do not indicate any need for extra protein in hard work. Strieck [3] carried out prolonged studies which were published in 1937 on the effect on a man of a minimum protein diet over a period of years, and showed that hard work could be carried out efficiently on very low protein diets.

In 1943, Ancel Keys [4] reviewed the available scientific evidence with enormous thoroughness and referred critically to 410 separate learned publications on the subject. He concluded :

> " Naturally, the protein intake must be adequate in amount and in essential amino-acids to maintain balance. This would be readily achieved with an intake of 40 or 60 grammes of protein a day. Additional protein may be desirable to build up a reserve of labile body protein for

[1] Cathcart, E. P., 1925, *Physical Rev.*, 5, 225.
[2] Wilson, H. E. C., 1934, *J. Physiol.*, 82, 184.
[3] Strieck, F., 1937, *Ann. Int. Med.*, 11, 643.
[4] Keys, A., 1943, *Federation Proc.*, 2, 164.

emergencies. On reasonably good diets such stores are increased by extra food, including proteins. A high carbohydrate meal taken before work has a sparing effect on nitrogen excretion during and after work. In some practical situations with long periods between meals the relatively slow digestion and absorption of proteinacious foods might be an advantage."

Meat and Work

Industrial workers *believe* that they need meat in order to carry out their day's shift efficiently. If this is so, it is quite clear that it is not the protein in the meat that is the significant factor. A diet composed of the usual types of foodstuffs will be found to derive about 10–12% of its calories from protein. This means that if a workman whose energy expenditure is, say, 3,600 calories is obtaining his daily calorie requirement, he will hardly be able to avoid consuming 90 g. of protein (1 g. of protein produces 4 calories, hence 90 g. produces 360 calories). Even when the conventional "safety margin" is added, the requirement for protein is rarely set at more than 70 g. daily or 1 g. per kilo of body-weight.

Another point worth remembering is that bread made from 85% extraction flour derives 13% of its calories from protein. The proportion even in the pre-1939 white bread was 12%. Thus a man whose appetite is satisfied on any normal food cannot fail to obtain his physiological needs for protein.

Meat, however, is not composed solely of protein. Can it be that it contains other ingredients which render it desirable, if not physiologically necessary, for those doing hard work? In 1865 Liebig established a factory in South America to make a preparation of meat designed to take advantage of the

valuable culinary qualities of the extractives of meat. Liebig's meat extract was prepared by chopping up fresh meat, heating it under pressure with a little water, filtering and evaporating the liquid to a brown, sticky consistency. This preparation has a strong meaty flavour and has maintained its popularity for more than eighty years in spite of a signal lack of enthusiasm for it in scientific text-books. The principal extractives of which Liebig's preparation is composed—substances called creatine, xanthine, hypoxanthine and carnosine—are incapable of being utilised by the body This fact was known to Liebig himself. " Meat extract," said Liebig as quoted by Hutchison and Mottram,[1] " cannot make us strong but it makes us aware of our strength."

We have in this statement the beginnings of the suggestion that extracts of meat act as stimulants. Hutchison and Mottram, summarising the accepted scientific thought of the 1940's, are doubtful of the evidence in favour of the " stimulating " properties of meat extract. " A stimulant ", these authors state, " must act either on the heart, quickening and strengthening its action, or upon the central nervous system, abolishing or lessening fatigue." More recently, however, new scientific discoveries have necessitated a change in our assessment of the nutritional significance of meat. These findings may have a bearing on the place of meat in the diet of industrial workers.

In the next chapter the normal nutritional significance in the diet of nicotinic acid, one of the vitamins of the B-group, is discussed. It was at the University of Wisconsin that it was first announced that meat was one of the richest sources of nicotinic acid.[2] The amount of nicotinic acid

[1] Hutchison and Mottram, 1940, " Food and the Principles of Dietics ", 9th ed., Arnold, London.

[2] Waisman and Elvehjem, 1947, " The Vitamin Content of Meat ", Lewis, London.

required by an active man is about 15 mg. daily. Usually this quantity can readily be obtained from the normal components of a diet supplying, say, 3,000 calories daily. Besides nicotinic acid and several of the other vitamins of the " B-group ", which we will discuss more fully in the next chapter, meat is now known to contain what is being called the " animal protein " factor.[1] This substance, whatever it may be, is not itself a protein, although it is associated with animal foods containing protein. It has been shown to be necessary for the well-being of a number of species of animals, and almost certainly is of importance for man.

Specific Dynamic Action

One further aspect of the nutritional significance of meat must be mentioned. All foodstuffs when they enter the body cause an outburst of heat which cannot be utilized in the production of mechanical energy. The amount of heat thus lost varies with the environmental temperature, but the magnitude of this *specific dynamic action*, as it is called, is of such an order that if in a unit time the basal energy needs of the body are 100 calories, about 140 calories will be expended if protein is given. Corresponding figures for the other nutrients are about 114 calories for fat and 106 for carbohydrate. It can thus be seen that the specific dynamic action of protein is highest. This wasteful effect is most pronounced at high atmospheric temperatures and when large amounts of protein foods are eaten at a single meal. The specific dynamic action of proteins is derived from the sum of the specific dynamic actions of the individual amino-acids composing the protein.

It thus appears that protein is an extravagant source of energy. For the production of energy by an industrial

[1] Ott, Rickes and Wood, 1948, *J. Biol. Chem.*, 174, 1047.

worker, carbohydrate and fat are more economical. Specific dynamic action produces heat, and since the specific dynamic action becomes greater as the environment becomes warmer, meat and other protein foods would appear to be undesirable for workers engaged on hot jobs. Specific dynamic action is in evidence up to three to six hours after protein is eaten. It is therefore more reasonable for an industrial worker doing work in a foundry or steel-rolling mill under hot conditions to eat his meat in the evening rather than during the course of his shift.

Conclusion

We can now reach the following conclusions :

(i) That protein as such is not specifically needed for the performance of physical work. Furthermore, when work-people obtain the calories they need from a normal variety of foods, they can hardly fail to obtain their nutritional needs for protein. The desire of workers for meat must therefore be considered separately from the question of protein.

(ii) Meat is useful as a source of fat for the provision of calories in a compact form.

(iii) The extractives in meat stimulate appetite, and hence encourage men to consume, either as meat or as other foods accompanying it, the calories they need for the efficient execution of their jobs.

(iv) Meat contains nicotinic acid and a number of other B-vitamins, including an " animal protein factor ". It is also a valuable source of iron.

(v) Finally, meat as a protein food possesses specific dynamic action leading to the conversion of a proportion of the calories of the diet into the form of heat.

At one time some athletes used to eat large amounts of meat while they were training ; but the modern tendency has been towards a simple diet of a normal type in which the amounts of food eaten are merely adjusted to provide the increased demands for energy arising from the physical expenditure of the athlete. Although there is no doubt that meat is a useful food for workers and others engaged on physical activity, recent studies on athletes include equal numbers of recommendations of a high meat intake,[1] which are balanced by reports of outstanding performance on vegetarian diets,[2] and of successful achievement on low intakes of protein.[3, 4]

When the facts themselves are not clear, it is impossible to reach a definite and sharp conclusion. The points listed above show that meat is useful, but not that it is essential for the industrial worker. The last words can perhaps best be given by two scientific workers separated in time by forty years.

In 1909, Crichton-Brown wrote : [5] " The success of the races, their vitality and energy, might almost be measured by the degree in which animal flesh has entered into their diet ". And in 1940, Cuthbertson, now Director of the Rowett Research Institute in Aberdeen, expressed himself in the following words after reviewing the whole range of dietary research : [6] " Statistically there is a high correlation between efficiency in its widest sense and a rich protein diet, and a low intake of animal protein is seldom coupled with high efficiency."

[1] Dupain, 1939, *Research Quart.*, **10**, 33.
[2] Wishart, 1934, *J. Physiol.*, **82**, 189.
[3] Chittenden, 1904, " Physiological Economy in Nutrition ", New York.
[4] Murphy, 1940, *Research Quart.*, **11**, 57.
[5] Crichton-Brown, 1909, " Delusions in Diet ", Funk and Wagnalls, New York.
[6] Cuthbertson, 1940/41, *Nutrition Abs. and Rev.*, 10, 1.

Chapter Five

ACCESSORY FOOD FACTORS

ALTHOUGH the existence of vitamin B was discovered, even if under another name, as early as 1887, and although Sir Frederick Gowland Hopkins pointed out in 1906 the essential nature of what we now know to be vitamin A and vitamin D, almost up to World War I in 1914, nutrition, as it was generally applied, restricted itself exclusively to calories, proteins, carbohydrates and fats. This conception of the subject omitted two important groups of nutrients, both of which are essential to health: these are minerals and vitamins. It is these substances which are comprised in the term " accessory food factors ".

In planning the British diet of 1918, the then Ministry of Food publicly condemned the use of fruit, tomatoes and vegetables as wasteful and unnecessary. Because, as is shown in Table 2, their calorie values are low, they were dismissed as being little better than coloured water in solid form. Similarly, because the importance of vitamin A was not fully understood, the Danes exported most of their butter. This led to the appearance of xerophthalmia followed by blindness among their children. A British garrison surrendered to the Turks at Kut, not because they did not have *enough* to eat, but because they did not know that their rations were deficient in B-vitamins and in vitamin C, enough of which could have been dropped to them

from a single aeroplane of those days to keep the defence going if only there had been understanding then of what the American physiologist, McCollum, soon after called "the newer knowledge of nutrition".

Industrial workers, as we have seen, have their basic needs for calories, and these calories must be derived from fat, carbohydrate or protein. Nevertheless it is probably true to say that more industrial diets fall short of the standard necessary for full health and efficiency through shortage of accessory food factors than from lack of calories.

Minerals

A long list of mineral substances is needed in a properly balanced diet. The minerals in the list can be divided into three groups, according to the general type of physiological purpose they serve:

(1) *As constituents of the body tissues.* Minerals in this group include phosphorus, iron, sulphur, zinc, copper and iodine present in muscle, blood corpuscles, liver or special structures such as thyroid gland.

(2) *As soluble salts needed to maintain the constancy of the body-fluids.* Important among this group are sodium, potassium and chlorine.

(3) *As constituents of the skeletal structure.* Some of the minerals in bones and teeth are calcium, phosphorus and magnesium.

Early in the present century it was discovered by Embden and Myerhof that phosphorus plays a part during the production of energy from muscle. During World War I, Embden, with this fact in mind, conceived the idea that since the phosphorus already in the body was concerned with the functioning of the muscles, the provision of *additional*

phosphorus would therefore *increase* the amount of muscular work a man could do. On the strength of this notion he was able to persuade the German authorities to provide a phosphate drink for enormous numbers of soldiers and workmen.

Unfortunately, Embden's reasoning, though plausible, was wrong. A mass of evidence, some of it mutually contradictory, was collected, but it is now agreed [1] that there is no proof that supplementary phosphate taken as a drink or as tablets or in food contributes in any way to a man's capacity for work or to his resistance to fatigue. Interest in dietetic phosphate has had an unhappy history. For example, the discovery that brain tissues contain a high proportion of phosphorus has led to the suggestion that foods rich in phosphorus, notably fish, would be " good for the brain ". It is regrettable that this also is not so.

Of all the minerals needed in nutrition, probably only iron, sodium and chlorine are of direct practical interest to the industrial nutritionist.

Iron

Iron forms a part of hæmoglobin, the red pigment in blood. A deficiency of iron in the diet, or an unusual loss of iron from the body, may lead to anæmia.

Anæmia is commoner among women than among men, since they have a more imperative requirement for iron, due to their monthly loss of blood. Its appearance in men, however, is by no means rare. It is, for example, associated with hæmorrhoids. Lassitude and tiredness are among the symptoms of anæmia. When female workers faint at the bench, the possibility of anæmia should be borne in mind.

The foods which contribute the most iron to the diet are

[1] Boje, 1939, *Bull. Health Org., L. of N.*, 8, 439.

liver and meat, egg-yolk and wholemeal flour. A fuller list is given in Table 16 below.

TABLE 16

The Iron Content of Common Foods

(Mg. per oz.)

Meat		*Vegetables*	
Liver	3·9	Spinach	0·9
Kidney	3·8	Green peas	0·5
Beef, corned	3·1	Watercress	0·4
Beef, average	1·1	Cabbage	0·3
Mutton	0·6	Carrot	0·2
Pork	0·3	Lettuce	0·2
		Onion	0·1
		Potato	0·2
Fish		Tomato	0·1
Sardine	1·1	Turnip	0·1
Kipper	0·6		
Herring	0·4	*Miscellaneous*	
Salmon	0·4	Curry powder	21·3
Cod, etc.	0·3	Cocoa powder	4·1
		Chocolate	0·9
		Peanuts	0·7
Dairy produce		*Pulses*	
Egg, dried	3·1	Haricot beans	1·9
Egg, fresh	0·8	Dried peas	1·3
Cheese	0·2	Lentils	2·2
Milk, Butter	Nil		
		Fruit	
		Dried apricot	1·2
Cereals		Dried fig	1·2
Oatmeal	1·4	Prune	0·8
Flour, wholemeal	1·0	Raisin	0·5
Flour, national	0·7	Blackcurrant	0·4
Flour, white	0·4	Apple, Plum, Pear, Orange, Lemon, Melon	0·1
Bread, wholemeal	0·7		
Bread, national	0·5		
Bread, white	0·2		
Barley	0·2		
Rice	0·2		

Salt

(sodium chloride)

This mineral nutrient is of particular practical importance to workers in industries where conditions are hot and ardu-

ous. We shall therefore postpone discussion of it until Chapter Nine.

Vitamins

A large group of substances, numbering two or three dozen, are to-day all classed as vitamins, and are known to be necessary in a properly balanced diet. Some of the better-known vitamins are listed in Table 17. This table is not claimed to be complete even at the moment I write. A. P. Herbert, the satirist, was a true prophet when he sang :

> There are three vitamins, not four,
> I have no doubt there will be more.

TABLE 17

Some Better-known Vitamins (1949)

1. Vitamin A.
2. *alpha* Carotene.
3. *beta* Carotene.
4. *gamma* Carotene.
5. Vitamin A_2.
6. Vitamin B_1.
7. Riboflavin.
8. Nicotinic acid.
9. Nicotinamide.
10. Pantothenic acid.
11. Biotin.
12. Pyridoxine.
13. Pyridoxal.
14. Pyridoxamine.
15. Inositol.
16. Choline.
17. Vitamin B_{12}.
18. *para*-Aminobenzoic acid.
19. Vitamin K.
20. Vitamin P.
21. Vitamin C.
22. Vitamin D_2.
23. Vitamin D_3.
24. Vitamin E.
25. Linolenic acid.
26. Linoleic acid.
27. Arachadonic acid.

In the normal circumstances of Western industrial life most of the substances shown above are present in the diet in adequate amounts without there being any need for the nutritionist to trouble about them. On the other hand, a shortage of vitamin A, of vitamin B_1 and other B-factors, such as riboflavin and nicotinic acid, and of vitamin C may easily occur in individual diets to a degree sufficient to hamper the efficient performance of the day's work.

Vitamin A

Vitamin A is present in milk, cheese, eggs and in very substantial amounts in liver. Vitamin-A activity is also

provided by carrots, tomatoes, sweet potatoes and green vegetables. The vitamin-A activity of these vegetables is not due to vitamin A itself, but to the presence of a yellow pigment, carotene, which is apparently convertible into vitamin A in the gut.

There is no evidence that muscular function has any direct or immediate relation to vitamin-A intake. Working efficiency may, however, be restricted by lack of vitamin A because of the effect of the vitamin on vision. This effect will be particularly significant where men are called upon to work in a dim light or where, as in the case of railway firemen working at night, they may need to look at a bright light one moment—for example, the fire-box of the engine—and at dimly illuminated objects, such as distant signals, the next.

Vitamin A is one of the chemical substances in the retina of the eye which enable light to be perceived. When the body becomes deficient in vitamin A the power of the eye to adapt itself to a dim light is impaired.[1] The use of liver in the treatment of night blindness was recommended in biblical times. However, the relation between night blindness and vitamin-A consumption is by no means as straightforward as was believed a few years ago. For example, many people can subsist for weeks or months without vitamin A before effects on night vision appear.[2, 3] In other people signs of defective dark adaptation appear in a few days.[4] Then again, by no means all cases of night blindness are due to deficiency of vitamin A. A third of the people with poor night vision observed in Labrador were apparently not deficient in vitamin A.[5] It has, for

[1] Wald, 1942, *Biol. Symposia*, 7, 43.
[2] Wald, Broula and Johnson, 1942, *Am. J. Physiol.*, 137, 551.
[3] Vitamin A Subcommittee M.R.C., 1945, *Nature*, 156, 11.
[4] Hecht and Mandelbaum, 1940, *Amer. J. Physiol.*, 130, 651.
[5] Steven and Wald, 1941, *J. Nutrition*, 21, 461.

example, been shown[1] that psychological and not nutritional factors can be responsible for night blindness.

Vitamin-A deficiency *can*, however, produce night blindness, and it is therefore reasonable to take special pains to insure that those workpeople whose duties are carried out in a dim light or under conditions of fluctuating illumination receive an ample vitamin-A supply. There is, however, little scientific justification for recommending[2] that enormous doses of vitamin A should be given even to aviators or others whose work demands great accuracy of vision. The full daily need for an optimum diet is shown in Table 1, and no advantage is obtained by exceeding it.

Besides its effect on vision, vitamin-A deficiency causes certain skin symptoms which may extend in modified form to the mucous surfaces of the nose, eyes and throat. Vitamin A has, in consequence, sometimes been miscalled the " anti-infective " vitamin. There is, however, no evidence whatever that the administration of vitamin A promiscuously to the employees in a factory in any way lessens the incidence of colds or other respiratory infections.

B-vitamins and Industrial Work

Vitamins of the B group have a much closer bearing than has vitamin A on work, since they are concerned with the release of energy by the oxidation of carbohydrate in the muscles. Vitamin B_1 is known to function in the normal breakdown of carbohydrate; and other members of the vitamin-B complex, notably riboflavin and niacin (nicotinic acid), are known to be concerned in other aspects of the same process. There is little evidence, however, that large supplementary doses of B vitamins improve work perform-

[1] Wittkower and Rodger, 1941, *Brit. Med. J.*, 2, 607.
[2] Bierman, 1940, *J. Phys. Therapy*, 21, 267.

ance in any way when the dietary requirements, which have already been discussed, have once been satisfied.

Vitamin B_1

Acute deficiency of vitamin B_1 leads to the disease beri-beri. Apart from the physical symptoms of the disease, which need not be discussed here, the frame of mind engendered by beri-beri is described as a feeling that " it is better to sit than to stand, it is better to lie than to sit, it is better to die than to live ". Subjective symptoms supporting such an outlook have been described in studies of experimental vitamin-B_1 deficiency.

Dr. Ancel Keys,[1] in the United States, carried out a careful study of the effect of deprivation of vitamin B_1. He studied a group of men doing their normal everyday work on a diet normal in all respects except that it was lacking in vitamin B_1. The first symptom he noticed was *lack of appetite*. A dietary deficiency which causes lack of appetite is obviously of significance for industrial workers who are being called upon to expend physical effort, and hence to consume calories. The men studied in Dr. Keys' laboratory showed few physical signs of malnutrition. The subjective effects of the deficiency of vitamin B_1, however, in addition to loss of appetite, were striking.

> " The deficient men were uniformly apathetic, disinclined to either physical or mental effort and depressed. All time free from tests and other set features in the programme was devoted to lying silently in bed. . . . It is notable that their lack of desire to eat was not limited to the experimental diet; for example, they were only mildly intrigued by the thought of beefsteak or fresh vegetables, which they had not eaten for seven months."

[1] Keys, *et al.*, 1945, *Amer. J. Physiol.*, 144, 5.

Vitamin B_1 is needed in the diet primarily for the utilisation of starch, sugar and other carbohydrates and for the utilisation of protein. The critical factor deciding whether or not a diet is adequately provided with vitamin B_1 is the proportion in it of sugar and of white flour. Of all foods, these are most strikingly lacking in the vitamin; at the same time vitamin B_1 is specifically required for their utilisation in the body. The requirement of vitamin B_1 by an individual worker is probably proportional to the intensity of the physical work he does; it is certainly proportional to the amount of calories he consumes from any source other than fat. It is therefore important to ensure either that the food eaten is itself a source of adequate vitamin B_1 or that sufficient of the vitamin is present in the diet from other sources. As a result of his researches, Dr. Keys has calculated that 0·23 mg. of vitamin B_1 per 1,000 calories of diet is sufficient; that is to say, 0·81 mg. is required daily by a man whose diet provides 3,500 calories. The figures given in Table 18 enable an assessment to be made of any diet to see whether this level is being attained.

Riboflavin

Insufficiency of riboflavin may occur in poor diets deficient in milk, eggs and meat. The signs of shortage are cracking and fissuring of the skin at the corners of the mouth, certain other skin symptoms, soreness of the tongue and a particular type of clouding of the eyes. Symptoms such as these are not uncommon. They *may* be due to many causes other than riboflavin deficiency; but, on the other hand, they do arise when the diet is insufficiently supplied with riboflavin. Numerous cases thought to be due to this form of vitamin shortage were observed among working people in the United States during the period of World War

II ; but when Professor Sydenstricker, the American expert, made a study in Britain under the auspices of the Ministry of Health, he was unable to discover more than a trifling number of people with symptoms attributable to riboflavin deficiency. It has since been suggested that because beer provides a material contribution of riboflavin in the quantities in which it is drunk, whereas spirits contain none, the British liking for beer may have been partly responsible for this state of affairs.

The amounts of riboflavin in a number of common foods are shown in Table 18.

Dr. Keys [1] has published an account of a careful study of men provided with a diet adequate in all respects except for riboflavin. On the basis of these experiments he has been able to show that 1·1 mg. of riboflavin per 3,500 calories (*i.e.*, 0·31 mg. per 1,000 calories) is sufficient to prevent their suffering any physical handicap even after five months on the restricted diet. The recommended allowance of the U.S. National Research Council (Table 1), which provides for optimum nutrition under any contingency, is 1·8 mg. daily.

Niacin (Nicotinic Acid)

A prolonged shortage of niacin will lead to the disease pellagra. This is uncommon in Britain ; but early symptoms of niacin deficiency are a certain form of dermatitis, diarrhœa and mental symptoms which may progress to dementia. As will be seen from Table 18, meat is the best source of niacin.

Dr. Ancel Keys [2] has carried out another practical experiment with niacin. Once again he maintained a group of men on diets in which the amount of the vitamin was re-

[1] Keys *et al.*, 1944, *J. Nutrition*, 27, 165.
[2] *Idem, ibid.*, p. 485.

stricted. He found that 6·5 mg. of niacin daily prevented the appearance of any evidence of physical deterioration.

Vitamin C

Many commonly eaten diets contain less vitamin A than is necessary to maintain an industrial worker in " positive " health. Yet vitamin-A activity can be obtained from two separate groups of foods: dairy produce, liver and eggs on the one hand, and fruit and vegetables on the other. Vitamin B_1 is provided by many cereal foods, by meat—particularly by pork—by potatoes and many other foods. Indeed, only sugar and white flour, white rice and the like are glaringly deficient in it. Riboflavin occurs in dairy products, in cereal foods, provided they are not too highly refined, and in many vegetables. Niacin occurs in meat; but it is also associated with the other B-vitamins in cereals. An industrial worker eating a substantial diet is likely, therefore, to obtain all these vitamins unless he is eating excessively large quantities of white flour and sugar. Vitamin C, however, must be derived almost exclusively from potatoes, vegetables and fruit, and it is not uncommon to find diets in which these foods do not occur or in which they are present only in small amounts. Furthermore, vitamin C is easily lost in cooking, and when food is kept hot loss of vitamin C becomes very large. Because of these facts, it is of practical importance to take pains to see that vitamin-C-containing foods are present in the diet of industrial workers.

Canteen meals are often " plated up " after they are cooked, and are then kept warm in hot cupboards so that the largest number of customers can be fed in the shortest possible time when the dinner hour begins. This practice causes a heavy additional loss of vitamin C. The provision

of salads has often been thought to be a good way of circumventing this loss. The problem is, however, one which may not be solved so easily.

Competition between Vitamin C and Calories

In many factories and offices there are people whose daily expenditure of muscular energy is small. These people may complain that the meals provided by the canteen are unsuitable. If the meals are held for any length of time in a hot cupboard, these complaints will be doubly justified. For these less active workers a salad forms a valuable and attractive component of a meal and can rightly serve as a source of vitemin C. For the heavy worker, however, a main meal must before all else provide calories to replace the energy expended in work. Salads are bulky, and provide only a negligible concentration of calories. It is reasonable, therefore, for a worker who must fill the not unlimited capacity of his stomach with the fuel necessary for his work to refuse salad and eat instead something more " solid " which will supply calories. Furthermore, unless the cooking at the canteen is unduly destructive, the substantial quantity of potatoes which a hungry man will eat may provide as much vitamin C as a salad or even more. We shall discuss this point again in Chapter Seven.

Acute shortage of vitamin C causes scurvy ; partial deficiency causes a roughening of the skin and delays the healing of wounds and abrasions. Not much vitamin C is needed to prevent scurvy ; a short while ago a report appeared in the *British Medical Journal*[1] of a case of scurvy being cured by the administration of a dose of 20 mg. of vitamin C. The

[1] Barnes, 1947, *Brit. Med. J.*, 1, 338.

Medical Research Council suggested that 30 mg. a day was sufficient for a good diet. There are, however, so many ways in which vitamin C can be lost—in cooking, in the wilting of vegetables, when meals are kept hot; it is even lost from the body when aspirin is taken. It is therefore understandable to find the U.S. National Research Council recommending 75 mg. a day for an optimum diet (see Table 1).

The danger of vitamin-C deficiency is greatest in the Spring. A glance at Table 18 shows that it is the steady fall in the vitamin-C content of potatoes that makes this so. When the new potatoes come into season in May, and Spring salads and early greens appear, many people feel a surge of physical well-being. This may be due to many reasons other than the generous supply of vitamin C, but if it *is* due to vitamin C, and if such a spurt in health is experienced by a group of factory workers, *then* it could be said that the industrial nutritionist has failed to provide enough vitamin C during the winter.

February, March and April are therefore the months to bring out the bottled gooseberries, the bottled black currants and tomatoes. They are the times to buy grapefruit and oranges and to serve what greens there are available and to put watercress into the sandwiches.

The Distribution of Vitamins in Foods

Table 18 is not intended to provide a complete list. It gives, however, some average values for the amounts of the vitamins we have been discussing present in a number of the commoner food commodities. In considering these figures it is especially important not only to take note of the concentration of each vitamin in an ounce of any individual food, but also to bear in mind the amount of that food which

TABLE 18

The Average Vitamin Content of Certain Foods

Vitamin A	International units per oz.
1. *Animal foods*	
Halibut-liver oil	600,000
Cod-liver oil	30,000
Ox liver	6,000
Butter	1,140
Margarine (vitaminised)	570
Cheese	370
Kidney	280
Egg	280
Sardine	77
Herring	42
Milk	30
Most meat	14
2. *Vegetable foods*	
Carrot	1,730
Spinach	1,230
Dried apricot	470
Watercress	470
Tomato	280
Prune	240
Cabbage	85
Green peas	47
Potato, onion Bread, flour, cereals	Nil

Riboflavin	Mg. per oz.
Dried yeast	1·37
Liver	0·85
Bovril, etc.	0·48
Cheese	0·14
Egg	0·11
Peanut	0·08
Beef	0·07
Pork	0·06
Mutton	0·05
Bread, wholemeal	0·05
Bread, national	0·03
Bread, white	0·01
Milk	0·04
Fish	0·04
Potato	0·02
Cabbage, watercress, etc.	0·02
Beer	0·01
Sugar	Nil
Dried yeast	1·00–2·00
Peanut	0·25

Vitamin B_1	Mg. per oz.
Bacon	0·17
Green peas	0·12
Liver	0·11
Bread, wholemeal	0·09
Bread, national	0·05
Bread, white	0·01
Mutton	0·04
Egg	0·04
Potato	0·03
Beef	0·02
Cabbage	0·02
Fish	0·02
Milk	0·01
Sugar	Nil
Vitamin C	
Black currant	57
Brussel sprouts	28
Cauliflower	20
Cabbage	20
Watercress	17
Orange	16
Grapefruit	14
Gooseberry	13
Lemon	12
Potato, new	8
Potato, Oct./Nov.	4
Potato, Dec.	3
Potato, Jan./Feb.	2
Potato, Mar. onwards	1
Tomato	7
Lettuce	4
Onion, carrot	3
Apple, plum, pear	1
Niacin	
Dried yeast	21·8
Bovril, etc.	17·0
Liver, Kidney	3·8
Peanut	2·6
Meat	1·3
Fish	0·6
Bread, wholemeal	0·6
Bread, national	0·3
Bread, white	0·2
Watercress	0·5
Potato	0·3
Cabbage	0·1
Apple	0·1
Sugar	Nil

can be consumed at a sitting. For example, milk contains only 30 i.u. of vitamin A per ounce, and is shown bottom but one of the animal foods given in the table. The content of vitamin B_1 and riboflavin is similarly unimpressive. Yet it is not uncommon, when milk is readily available, for a working man to drink a quart of milk a day. An Imperial quart contains 40 oz. This quantity will provide 1,200 i.u. of vitamin A, which is at least 25% of the total daily needs, 0·48 mg. of vitamin B_1, or about half of the amount found by Keys to be sufficient, and 1·6 mg. of riboflavin, which is probably enough for the day's requirement.

An opposite example is provided by the iron content of curry powder. Curry powder contains 21·3 mg. of iron per ounce—an extraordinarily high concentration. Yet, in spite of this, curry powder is not a particularly important contributor of iron to the British diet, because the daily amount consumed is so small. Bread, however, of the type eaten since 1940, which contains 0·5 mg. per oz., is one of the principal contributors of iron.

The list of vitamin-A-containing foods shows that liver among the animal foods is a predominant source. Butter is a useful daily contributor, as also is margarine when, as is the case in the United Kingdom, it is enriched with vitamin A.

Among vegetable sources of vitamin-A activity, carrots are outstanding. The concentration of vitamin in them is high, and they are commonly eaten in substantial amounts. Green vegetables also provide vitamin-A activity, and the concentration in them runs broadly parallel with their greenness. Such vegetable as kale, turnip tops and sprouting broccoli and the miscellaneous leaves sold as " greens " have a good vitamin-A content.

The list of concentrations of vitamin B_1 must be considered

in relationship with the fact that at least 0·23 mg. of vitamin B_1 is required per 1,000 calories consumed. Wholemeal bread provides 70 calories per ounce. It therefore requires 14 oz. to supply 1,000 calories. There is in this amount of bread 1·22 mg. of vitamin B_1, or more than five times the amount needed for the utilisation of its own calories. White bread of the pre-war quality, on the other hand, contained only approximately 0·21 mg. of vitamin B_1 per 1,000 calories. It therefore contributed nothing to the diet, and indeed possessed barely enough of the vitamin for its own utilisation; while sugar, of which 9·2 oz. provides 1,000 calories, is entirely devoid of vitamin B_1, and in consequence its consumption creates a drain on the total vitamin-B_1 supplies of the diet.

Vitamin Tablets for Industrial Workers

Table 1 in Chapter 1 set out the amounts of vitamins recommended for a target diet so good that no addition could improve it. If we wish to know whether the diet of a group of people can be improved, we must first find out what they are eating, and then calculate its nutritional value. If the result for any vitamin is less than the allowance recommended, we ought then to seek to remedy the situation, first by adding a food which will contribute the vitamin in question and, secondly, if need be, by means of the vitamin itself as a tablet or concentrate. The second procedure has been adopted in Britain for vitamin A and vitamin D, which are added in concentrated form to margarine. Usually, however, it is sounder nutritional practice to provide nutrients by a properly designed choice of food.

When a diet contains vitamins and other constituents in adequate amounts, *no benefit is obtained by adding more.*

Vast sums of money and uncounted thousands of vitamin

pills have been consumed in the United States by industrial workers who have been misled, either by ignorance, by fear or by disingenuous advertising, into believing that such ministrations would improve health and efficiency. Tests carried out in Britain during 1941 and 1942 by the Ministry of Health failed to show that the administration of "shot-gun" pills of mixed vitamins in any way improved the health of 214 men working at smelting furnaces.[1]

Vitamins are essential components of the diet. Each vitamin performs its own specific function in nutrition. We need to apply knowledge of the requirements of the separate vitamins and of their distribution in foods if we hope to provide an optimum-diet to the workers for whom we are responsible. But beyond their particular effectiveness, vitamins have no special magic to offer.

[1] Magee, 1946, *Brit. Med. J.*, i, 475.

Chapter Six

FOOD WASTAGE AND THE EFFECTS OF COOKING

IN order that the principles of nutrition may be applied with full effectiveness to the feeding of industrial workers, it is necessary for there to be an understanding of the relationship between the nutritional value of the raw food supplies coming into the factory, or into the town in which the workers live, and the value of the diet eaten by them after a series of losses and changes have occurred.

The average *requirement* of the whole British population for energy in 1939 was, as far as could be determined, 2,590 calories a head.[1] This average figure is based on the numbers of children, of women and of workers of varying degrees of activity and upon their individual energy needs. The national food *supply* at this date provided 3,000 calories a head. There was, therefore, a margin of 410 calories, or 15·8%, which can be considered to have been wasted. Some of this margin was not entirely lost, but was perhaps fed to domestic animals. In 1945 and 1946, when food supplies were dwindling, the *per capita* calorie value provided 2,880 calories to cover a *per capita* requirement of 2,550 calories. The margin of loss by wastage in distribution had therefore been reduced to 12·9%.

Where large numbers of individuals are to be fed in

[1] "Food Consumption Levels in the United Kingdom", 1947. Cmd. 7203, H.M.S.O.

Service messes and elsewhere, it is usually found that the margin for which allowance must be made if the full nutritional needs of the people being served are to be met is of the order of 10% to 15%.

Losses occur at all stages of food handling, and if the quantitative aspects of nutrition are to be studied in detail, careful allowance must be made for them. For the present discussion, it is most fruitful to concentrate our attention on the wastage of nutrients likely to occur after the food has arrived at the home of the consumer or at the factory canteen.

Wastage of Inedible Material

The first losses cannot strictly be called wastage. There is a loss of weight in fish due to the inedible nature of bones and often of part of the skin. Parts of certain vegetables are considered to be inedible. The skin of potatoes can be

TABLE 19

The Average Proportions of the Purchased Weight of Foods which are Wasted as Inedible

	%		%
Green Peas	60	Carrots	20–25
White Fish, Cod, etc.	45	Lettuce	20
Melons	45	Beef, good quality	17
Kippers	40	Mutton	17
Bananas	40	Prunes	17
Turnips	35	Tomatoes	15
Cabbage	30	Watercress	15
Cauliflower	30	Pork	15
Herrings	30	Dates	14
Coconuts	30	Eggs	12 (shell)
Peanuts	30	Bacon	12
Potatoes, old	25–27	Apricots	8
Spinach	25	Raisins	8
Oranges	25	Plums	6
Stewing Beef	25	Onions	5
Pears	25	Cheese	5 (rind)
Apples	20		

eaten when the potatoes are new, but it accounts for a loss rising from 7% to 25% of the gross weight of old potatoes. The approximate magnitude of some of the losses of this kind is shown in Table 19.

These figures show the proportion of foods which is inedible. The amounts which are not eaten are often very different from these amounts, and are discussed later. Tables of food composition are available which make allowance for the inedible fraction. These tables give the nutrient content of the *edible portion* of 100 parts of foodstuff weighed in the form in which it is commonly bought and sold. They are often loosely called " E.P." tables, as opposed to those which give the composition of the food directly in its purchased form, which are known as " A.P." tables ; these letters signify " as purchased ".

Kitchen and Plate Wastage

A second form of wastage is that which occurs in the kitchen. This is made up of direct loss of food during preparation and the loss of nutrients occasioned by the cooking processes. Wastage in the preparation of foods differs markedly with different commodities. There is, for example, a heavy loss in scrambling eggs, amounting to 13% of the total protein. This includes 1·5% of protein which sticks to the shell of the egg, 6·5% remaining in the bowl and 3·6% on the spoon.[1]

The waste of fried fish may amount to 40% for sole and 50% for haddock, partly due to cooking loss, but mostly to wastage on the plate. For all fish containing bones the plate waste tends to be substantial. Andross [1] gives figures of 60% for the waste of the edible parts of baked plaice and

[1] Andross, 1946, *Proc. Nutrition Soc.*, 4, 155.

steamed whiting, 35% for boiled salmon and 36% for grilled herring.

Inedible Weight and Wastage of Meat

The difference between the nutrient content of the meat bought by a works canteen and the nutrient value of what the worker is given to eat may be enormous. Andross,[1] writing in 1946, stated: "Few people consume their meat fat, and some eat only about a third of a meat helping. This shows the futility of assessing individual food intake from the amounts served." Some of the figures of the losses for meat given by this author are shown in Table 20. The first

TABLE 20

Cooking Losses and Plate Waste of Meat

	Cooking waste, %.	Plate waste, %.
Roast beef, rolled, British	46	33
Grilled chop, gigot, British	40	45
Grilled chop, gigot, New Zealand	40	39
Roast beef, rolled, Argentine	40	45
Roast mutton, loin, British	37	41
Grilled steak, fillet, Australian	36	25
Roast sirloin, Argentine	34	48
Roast beef, ribs, British	34	47
Roast sirloin, British	30	37
Roast mutton, loin, New Zealand	30	56
Grilled steak, fillet, Argentine	29	26
Roast beef, ribs, Argentine	26	77
Roast mutton, leg, British	26	16
Braised steak, shoulder, Argentine	25	33
Grilled chop, British	23	28
Roast mutton, leg, New Zealand	22	44
Stewed steak, shoulder, Argentine	19	42
Braised steak, shoulder, British	19	15
Stewed mutton, neck, New Zealand	18	37
Grilled steak, fillet, British	14	21
Stewed mutton, neck, British	13	37
Grilled chop, loin, New Zealand	13	44
Stewed steak, shoulder, British	12	21

[1] Andross, 1946, *Proc. Nutrition Soc.*, 4, 155.

column of this table gives the loss of weight occurring in cooking. Part of this is due to bone, part to loss of moisture and part to a loss of fat and protein, some of which may not result in net waste, but which may be recovered as dripping and gravy. The second column shows the average amounts, by weight, of the waste of the cooked meat left on the plate.

These figures emphasise one of the difficulties of assessing the nutritional value of an individual meal. The results shown do not necessarily apply to all conditions of catering. They are based on experiments in which the cooking methods were standardised and in which standardised ovens with controlled temperature regulation were employed. The plate waste from mutton consists of skin, fat and the bone. For beef the waste is fat and skin. Rib roasts have a high proportion of bone to meat. Rolled roasts have a high wastage because inedible material becomes rolled inside.

The moral of Table 20 is clear: only part of what is weighed by the butcher has nutritional value for the person for whom it is intended. The skilful canteen supervisor can, however, reduce loss of food. For example, if fat, skin and bone are removed from the meat before it is served, the fat can be rendered down and used for cooking, and the skin and bones used for stock. The custom, which is widely followed in industrial canteens, of cooking meat and then allowing it to cool so that it may be carved cold, has an object other than nutrition. It is that slices may be cut unbroken and very thin and the meat thus appear to the diner to be larger. There is, however, no evidence as to whether the reduction of palatability of the cold meat reheated, which is a characteristic and dreary feature of many canteen meals, itself causes more plate waste than would be occasioned by the more broken appearance of the meat carved hot.

The Wastage of Vegetables

The waste of vegetables is notoriously great. Here again Andross has provided the most comprehensive available information. It is well known that wastage may vary widely in different circumstances. It could often be reduced. For example, the wastage from vegetables bought in a wilted condition is very high. Potatoes which blacken during storage are wasted.

The weather affects the quality of vegetables. The variation in wastage occurring during the preparation of vegetables in four separate years is shown below.

TABLE 21

Waste in the Preparation of Vegetables as a Percentage of Purchased Weight (*Andross*, 1946)

	%
Broad beans	67–72
Green peas	60–65
Leeks	30–75
Broccoli	50–60
Kale	40–56
Brussel sprouts	33–50
Cress	30–45
Cabbage	40–41
Spinach	25–64
Beetroot	40–50
Carrot, old	30–50
Turnip	30–54
Parsnip	25–40
Potatoes, old	23–40
Lettuce	24–26
Onion	10–20
French beans	3–6

Once again we see that a high proportion of what is brought into the kitchen as food never reaches the plate of the consumer. And of that a further amount is refused.

Plate Waste Expressed in Terms of Nutrients

The loss of nutrients due to plate waste at meals has been studied in various circumstances.

From a group of thirty-five meals served at a Government canteen, the plate waste of protein was 6·5%, of fat 3·2% and of carbohydrate 11·4%. In another canteen college students wasted 11% of the protein served to them, 4% to 10% of the fat and 1% to 2% of the carbohydrate.[1]

Wastage varies with the quality of the cooking and the nature of the meals. For example, at a London school the waste of the main course was 21% by weight when roast beef and vegetables were provided, 13% when the meal was meat pie and only 7% for corned beef. At another school, however, the wastage when these same dishes were served was 14%, 9% and 14% respectively. Waste, it would seem superfluous to say, can be greatly reduced when a real effort is made to reduce it. For example, at three London schools where studies were made simultaneously it was found that the average plate waste of all food together was 3% by weight at the first school, where successful catering was achieved, 7% at the second and 18% at the third school.

The Effect of Cooking on the Nutritional Value of Food

We have now discussed the losses which occur during the preparation and cooking of a number of different kinds of food. Part of this waste is preventable, and it is therefore important for those responsible for the nutrition of industrial workers to appreciate the magnitude of the differences which may exist between well-run and badly-run canteens.

A second and more fundamental source of loss is the

[1] Andross, 1946, *Proc. Nutrition Soc.*, 4, 155.

destruction of nutrients due to the actual processes of cooking.

At the outset it must be appreciated that *for almost all foods the process of cooking leads to an improvement in nutritional value.* When food is unpalatable, people will eat less of it than they need for the efficient execution of their work. Well-cooked food encourages workers to eat and accelerates digestion and absorption by increasing the flow of digestive juices in the mouth and stomach. We have already seen in Table 20 something of the magnitude of the plate waste which can occur " normally ". Bad cooking and repellant surroundings are the most significant factors in causing the failure of plans for industrial feeding to reach their desired nutritional aims. However, besides its beneficial effect, cooking also has a harmful effect on certain of the nutritional qualities of foods.

Losses of Mineral Salts

The earlier scientific literature contained a great deal of information about the amounts of mineral salts which are lost from vegetables during cooking. It now appears, however, that while calcium salts may be dissolved out of vegetables into the cooking water, if the water is " hard ", calcium salts from the water may become added to the vegetable and a net gain result.[1] Other salts, notably sodium, potassium, iron and phosphorus, are also leached out of vegetables during the process of cooking. Stewart [2] has shown, however, that these losses are of little nutritional significance.

Losses of Vitamin C—Vegetables

The greatest danger to vegetables during cooking is a loss of vitamin C. Because potatoes and vegetables are by far

[1] Ziegelmayer, 1931, *Z. Ernähr.*, 1, 25.
[2] Stewart, 1946, *Proc. Nutrition Soc.*, 4, 164.

the most important contributors of vitamin C to the British diet when fruit is scarce, destruction of vitamin C in these foods is a matter of nutritional importance. The vitamin is lost in three ways: first, it becomes dissolved in the cooking water; secondly, when the plant cells become disrupted an enzyme within them reacts with vitamin C and quickly destroys it. The enzyme is itself destroyed, however, when the cooking water becomes hot. Thirdly, heat in the presence of air destroys vitamin C.

The magnitude of the losses in cooking has been reviewed by Olliver.[1] Figures quoted in the literature vary very widely, but the losses to be expected are probably as follows:

	Percentage of vitamin C lost in cooking.
Cabbage	40–65
Cauliflower	25–45
Kale	65–85
Brussel sprouts	25–50
Spinach	25–35
Green peas	45–65
Runner beans	35–55

A number of recommendations have been made for minimising these losses.

1. Since vitamin C is soluble, an excessive amount of water should not be used in boiling vegetables. Moderate variations in the quantity of water, however, do not seem to be of importance. Steaming may be more economical of vitamin C than boiling. On the other hand, destruction of vitamin C increases continuously with the time of steaming. Thus if we assume that 50% of the vitamin will be lost in boiling cabbage, steaming for thirty minutes will destroy about 40% of the vitamin C; but if the steaming continues for fifty minutes the loss will have increased to some 60%.

[1] Olliver, 1946, "The Nation's Food", Soc. Chem. Ind., London.

The addition of salt to the water in which vegetables are being cooked has no significant effect on the loss of vitamin C.

2. The important factor in cooking vegetables on a large scale is the rapidity with which they are brought to boiling point. Macrae[1] has pointed out that when cabbage is put into a boiler in small lots so that the water never goes "off the boil" during the time the whole of the charge is being added, the vitamin-C content of the cooked material may be seven times that of cabbage produced from a batch all of which has been dumped in one lot into the water, the temperature of which has in consequence fallen for a prolonged period.

3. The final important factor in the preparation of cooked vegetables with a high vitamin-C content is the reducing to the minimum of the time during which the prepared food is kept hot.

TABLE 22

Loss of Vitamin C from a Meal during Storage on a Hot Plate

	Vitamin C content (Thompson).			
	Amount, oz.	Freshly cooked, mg.	After 30 mins. storage, mg.	After 60 mins. storage, mg.
Cabbage . .	4	21	18	14
Mashed potatoes	4	14	7	6
Total . .		35	25	20
Percent loss, %		—	29	43

If we assume that 60% of the original vitamin C of the raw greens has been lost in cooking, it is painful to realise that

[1] Macrae, 1944, *Proc. Nutrition Soc.* 1, 99.

30% of what remains may be destroyed if the vegetable is kept hot for half an hour, and the loss may rise to 55% in an hour.[1]

Thompson[2] has shown the effect of keeping a canteen meal warm when it is " plated up " on a hot plate (see Table 22).

Losses of Vitamin C—Potatoes

Losses of vitamin C from potatoes are less severe than those from green vegetables, principally because potatoes do not appear to contain the destructive enzyme. They can therefore be put into cold water and brought to the boil, or put in bulk into boiling water, without affecting the loss of vitamin. Average losses in cooking potatoes are :

	%
Boiled in their skins	15
Baked in the skins	20
Fried	30
Boiled	50

Some additional loss occurs when potatoes are mashed, and the more thoroughly and " creamily " they are mashed the *greater is the loss* of vitamin C.

The principles to be followed to minimise the loss of vitamin C in cooking can now be seen to be :

1. Vegetables must be fresh and unwilted. When the cells wilt, the vitamin is destroyed by the enzyme released.
2. Green vegetables should be raised to boiling temperature as quickly as possible.
3. Food which is designed to serve as a source of vitamin C ought not to be " kept hot ".

[1] Olliver, 1946, " The Nation's Food ", Soc. Chem. Ind., London.
[2] Thompson, 1936, *Proc. Nutrition Soc.*, 4, 171.

Vitamin C has been studied in some detail in industrial catering, first, because it is so highly susceptible to destruction and loss and, secondly, because it is not widely distributed: it is, indeed, almost entirely restricted to fruit and vegetables. Nevertheless, it is important for us to maintain our sense of proportion. Vitamin C is only one nutrient in a diet of complex composition. We have already discussed calories, which must always have paramountcy, and there are other nutrients. If the day's diet already contains say 30 mg. of vitamin C, there is no harm in reheating cabbage to make "bubble and squeak" for the night shift, even though all its remaining vitamin will be destroyed in the process.

Salads

Finally, there are salads. Cooking losses can of course be avoided entirely if cabbage, for example, is eaten raw. In many diets, notably those intended for people with low energy requirements, salads are a valuable source of vitamin-C and vitamin-A activity. But heavy workers may not like them, and if they do not there is no nutritional reason for attempting to make them eat them.

Raw vegetables are bulkier than cooked ones, and whereas a person can easily eat 4 oz. of boiled cabbage at a sitting, he will probably find 1 oz. of raw cabbage or lettuce quite enough. If we take these figures as a basis for calculation, we can see that the amount of vitamin C obtained from the cooked vegetable is greater than that from the raw salad. Figures are shown below.

	Vitamin C, mg.
A convenient serving of lettuce (1 oz.) provides	3
A convenient serving of raw cabbage (1 oz.) provides	15
A convenient serving of cooked cabbage (4 oz.) provides	20

Although 60% of the original vitamin C in cabbage may be lost during cooking, about four times as much boiled cabbage can be eaten at a sitting, and more vitamin C will therefore be obtained from cooked than from raw cabbage.

There is one further point that must be borne in mind in considering the nutritional value of raw vegetables. It applies more particularly to countries outside the United Kingdom where dysentry is a common disease. *Where this disease and others such as typhoid, which are spread by infected water, occur, salads and raw vegetables should on no account be used.* Military medical officers have claimed, with excusable exaggeration, that lettuce was the greatest danger met by British troops in India!

Other Effects of Cooking

The effect of cooking on nutrients other than vitamin C and on foods other than vegetables is surprisingly small. Certain changes in the nature of the protein and some loss of minerals occur when meat is cooked, and there may be some loss of digestibility (which would imply that we would do better to eat meat raw),[1] but McCance and Shipp,[2] after a comprehensive study, concluded that, however it is cooked, meat is completely digested and loses little if any of its nutritional value. Similar conclusions are true for fish.

Cooking breaks open the starch grains in cereal foods and in potatoes, and markedly improves their digestibility thereby.

Vitamins of the B group are susceptible to heat to varying degrees. Vitamin B_1 is most easily destroyed, and is, for example, almost entirely lost at the high temperatures

[1] Morgan and Dern, 1934, *J. Nutrition*, 7, 367.
[2] McCance and Shipp, 1933, Sp. Rep. Ser. Med. Res. Council, London. No. 187.

required for the manufacture of biscuits. This vitamin is also susceptible to alkalies, and may be largely destroyed when certain types of baking-powders are used in bread-making. There is a loss of about 8% of vitamin B_1 when yeast is used in making white bread. The loss for 85% extraction flour is about 27% and for wholemeal the loss is 35%.[1] The increased temperature of toast-making causes additional loss.[2]

Riboflavin and niacin are less susceptible to destruction than vitamin B_1. Vitamin A is also comparatively resistant to cooking.

What are the conclusions to be drawn by the practical caterer and nutritionist from all this information? I think they are these:

1. First, although industrial diets have to be planned from the basis of purchasing and procurement, a precise estimate of the *amounts* of food eaten and of nutrients ingested cannot be made without knowledge of the proportion of inedible material included in the bought weight. The figures given in Tables 19, 20 and 21 are only averages; but they show the order of magnitude of the losses which will be encountered.
2. Next we come to kitchen and plate waste. This is the core of the problem. The scientist can be expected to conduct research and to know the literature of nutrition and physiology. Informed industrialists and caterers are aware of the protein, vitamin and mineral requirements of working men and women; but the fact remains that if the meals provided are badly cooked or badly served or otherwise unacceptable, then wastage will be high. A nutritionally

[1] Dawson and Martin, 1942, *J. Soc. Chem. Ind.*, **61**, 13.
[2] Downs and Meckel, 1943, *Cereal Chem.*, **20**, 352.

admirable meal is no good if the people for whom it is intended do not eat it.

3. Finally, cooking losses must be considered. In brief, it can be said that, although certain losses of minerals occur and the heat and moisture of cooking processes cause some destruction of vitamin B_1, riboflavin and other factors, the only important damage likely to be caused by cooking and by keeping food hot is loss and destruction of vitamin C.

Chapter Seven

MEAL FREQUENCY AND THE WORKING DAY

It has sometimes been said that eating is a matter of habit. This means, perhaps, that people become accustomed to having certain types of meals at certain times of day. Industrial workers who like the meal pattern with which they are familiar often believe that any change in habit would be harmful to their efficiency. This, however, is seldom true. It appears, indeed, that men and women are adaptable within wide limits and, so long as their daily nutritional requirements are provided, industrial and muscular efficiency can be maintained under a variety of conditions and with varying numbers of meals variously timed. There are, however, a number of important scientific considerations which bear on the matter. And the practical importance of meal frequency and timing is obvious.

The fuel which enables muscular work to be done is glucose, which is carried to all parts of the body by the blood. Glucose is chemically classified as a sugar. It is derived in the body from sugar, from the carbohydrate of which flour and other cereals are largely composed, and it is also produced from protein. The glucose in blood is quickly supplied by almost all normal foods, and no physiological benefit is derived from consuming glucose obtained as such from a chemist's shop.

The effectiveness of carbohydrate—that is, starches and

sugar—as fuel for muscular work has been demonstrated experimentally on dogs. For example, it has been shown that an animal could keep running for seventeen hours if it was given carbohydrate, whereas it was exhausted after four and a half hours if it was not.[1] Similar experimental studies showed that carbohydrate was a more effective muscular fuel than fat.[2] Dr. Ancel Keys,[3] however, has pointed out that the ideal dietary for people who have to do muscular work cannot be determined by short experiments with highly abnormal diets. The capacity of the human organism for adjustment is such that marked differences in the composition of the diet are attended only by small changes in muscular efficiency, and the performance of work is apparently largely independent of these.

The physiologist speaks with authority when he says that blood glucose is the ultimate source of physical energy. But he falls into error when he goes farther than that and attempts, without wider knowledge, to enter the field of the industrial nutritionist. For example, it is known that immediately after a meal the concentration of glucose in the blood rises, as carbohydrate is being absorbed from the intestine. In normal individuals this increased concentration quickly falls to normal again. In 1935, however, two Harvard physiologists [4] reported that this raised glucose concentration was accompanied by a markedly improved muscular efficiency and contended that, in consequence, it would be good practice to give factory workers frequent small meals, in order consistently to raise the amount of glucose in their blood, and hence to improve their industrial output. This recommendation

[1] Dill, Edwards and Talbott, 1932, *J. Physiol.*, 77, 49.
[2] Christensen and Hansen, 1939, *Skand. Arch. Physiol.*, 81, 160.
[3] Keys, 1943, *Federation Proc.*, 2, 164.
[4] Haggard and Greenberg, 1935, "Diet and Physical Efficiency", Yale Univ. Press.

has since been shown to be right—but for the wrong reason.

In 1943 the Western Electric Company in America arranged to isolate for observation a group of women who were assembling telephones. Elaborate records were kept over a period of two years of the physique, incidence of sickness, work output and general efficiency of this group. Details of a prolonged series of tests have been published at length. The whole investigation, which is now a classic, is called the Hawthorn Experiment.[1] These were the results :

When the women were given extra snacks and cups of tea, their output went up. But when they were given a short rest without any snack, their output increased also. When the lighting at their benches was improved, output improved ; and it did so similarly when the ventilation was modified. Most remarkable of all was the observation that when the snacks and rest-pauses were withdrawn and the lighting and ventilation gradually brought back to their original state—output still continued to increase, whereas that of the main body of workers, who were not being made an object of experiment, remained unchanged throughout.

This experiment and our discussion so far teach two lessons about workers doing jobs of moderate activity :

(*a*) Provided the daily diet supplies the full needs for nutrients, the number of meals into which it is divided does not appear to be crucial.

(*b*) The nutritionist must always remember that industrial efficiency is influenced by very many factors other than diet.

[1] Rothlisberger and Dickson, 1946, " Management and the Worker ", Harvard Univ. Press.

The Number of Meals Needed by Heavy Workers

As we have already seen, under normal conditions the level of glucose in the blood is maintained at a constant value. Physiological studies on men have shown that severe but not exhausting exercise causes a slight rise in blood glucose. That is to say, the body adjusts itself to the work by releasing an additional supply of fuel for the muscles. The same effect occurs with intermittent exercise.[1] Light work does not change the glucose concentration at all. Long-continued and very exhausting exercise, however, does lead to a depletion of the blood glucose. For example, marathon runners who reach a state of collapse have far less than the normal amount of glucose in their blood.[2]

This degree of exhaustion is never found in industry. Men doing heavy work over prolonged periods give themselves, knowingly or unconsciously, pauses for rest during the performance of their labour, and depletion of glucose in their blood has never been shown to be a limiting factor for the efficient execution of heavy industrial work. Nevertheless, experience in many industries has led to an informed opinion favourable to mid-morning and mid-afternoon rest periods during which food is eaten. And experimental studies in the Laboratory of Physiological Hygiene of the University of Minnesota support the practice of between-meal feeding when extremely hard work is being performed.[3] These experiments, however, provided no evidence of any physiological advantage at less extreme levels of muscular activity.

[1] Gemmille, 1942, *Physiol. Rev.*, 22, 32.
[2] Best and Partridge, 1930, *Proc. Roy. Soc.*, London, B. 105, 32.
[3] Keys, 1943, *Federation Proc.*, 2, 164.

What Should be the Composition of a Meal ?

The science of nutrition, as we have seen, can provide precise information about the amount of fuel required for a day's activity and about the amounts of vitamins and other nutrients needed to maintain the human body as an efficient machine. This information, however, is applicable to the requirements for twenty-four hours rather than to the design of a single meal.

A meal must possess certain qualities to fit it for the environment in which it is to be eaten ; but the consideration which must carry the greatest weight with those responsible for its preparation is : does it fit into the pattern of the total day's diet and contribute nutrients in the right amount so that within the whole day the industrial worker obtains his or her complete needs ? The desirable composition of any one meal, therefore, is affected by the nature of the other meals eaten in the same day.

Some Examples of Meals in Practice

Let us now review a number of examples of different meal patterns and the different types of communal meals specially arranged to fit into them. We shall first discuss the nutritional contribution of *a single, hot canteen meal* provided for one group of heavy workers, and then compare it with the nutritional value supplied in the form of *two less heavy meals* to a second group of workers doing a different but equally arduous job.

(a) *A Single Canteen Meal for Shipyard Workers*

The first group consisted of shipyard workers on the Clyde. Their daily diet was made up of six meals, as follows :

Meal 1. Breakfast at 7.30 a.m. (bread, butter, tea).

Meal 2. "Piece" eaten at work at 9.30 a.m. (bread, butter, jam, cheese).

Meal 3. Canteen dinner at midday. (This was a substantial meal of meat and two vegetables, sweet and tea.)

Meal 4. "Piece" eaten at about 3 p.m. (bread, jam, cheese).

Meal 5. Tea at home at 6 p.m. (bread, butter, fish and chips, or ham, jam, cheese, cake, tea).

Meal 6. Supper at about 10 p.m. (bread, butter, biscuits, tea—the evening consumption of beer has been included in calculating this meal).

To show the way in which the nutritional value of each meal and the contribution of the canteen meal to the whole daily diet may be calculated, some of the nutrients provided by a typical series have been worked out in the table opposite. The figures used for calculation are mainly those given in Tables 2, 12, 13 and 18. Other more complete tables are readily available [1, 2] to those who wish to make more thorough studies of this nature. Further details are given in the next chapter.

The figures shown are representative of many diets found in practice. The total calories and protein are probably fully sufficient (see Table 1); the vitamin A is undesirably low; and the vitamin C sufficient, but perhaps not optimal. The consumption of other nutrients—B-vitamins, calcium, iron, etc.—which can be calculated in a similar manner, was found to be adequate.

There are two practical points of interest in Table 23. The

[1] McCance and Widdowson, 1946, "Chemical Composition of Food", Med. Res. Council, Sp. Rep. Ser. 235.

[2] "Nutritive Value of Wartime Foods", 1945, Med. Res. Council, War Mem. No. 14.

TABLE 23

Typical Nutritional Values of Daily Meals Eaten by a Group of Shipyard Workers

	Food, oz.	Calories.	Protein, g.	Vitamin A, i.u.	Vitamin C, mg.
I. *Breakfast*					
Bread	4½	320	11	0	0
Margarine	⅖	87	0	230	0
Tea *	10	50	1	40	0
		457	12	270	0
II. "*Piece*"					
Roll	2	142	5	0	0
Butter	⅕	42	0	230	0
Cheese	½	58	3	180	0
		242	8	410	0
III. *Canteen dinner*					
Roast beef	3½	311	15	50	0
Boiled potato	5	105	3	0	10
Boiled cabbage	3	21	1	250	25
Yorkshire pudding	3	186	6	0	0
Steamed jam roll	4	248	4	0	0
Custard	2	66	2	40	0
Tea *	9	45	1	40	0
		982	32	380	35
IV. "*Piece*"					
Bread	1¼	89	3	0	0
Jam	½	35	0	0	1
Tea *	9	45	1	40	0
		169	4	40	1
V. *Tea*					
Kipper	6	362	32	300	0
Bread	3	213	7	0	0
Butter	½	105	0	570	0
Tea *	18	90	2	80	0
		770	41	950	0
VI. *Supper*					
Beer *	60	600	6	0	0
Biscuits	1	107	3	0	0
Tea *	9	45	1	40	0
		752	10	40	0
Total day's consumption		3,372	107	2,090	36

* For the sake of uniformity tea and beer are expressed in ounces; there are 20 oz. in 1 pint.

first is the unequal contribution of calories made by each of the daily meals. The canteen dinner, for example, although one meal out of six, provided 30% of the day's calories. Even more striking, however, is the fact that this one meal supplied 97% of the day's vitamin C. We can now understand the importance attached to proper cooking methods which avoid the destruction of this vitamin; the emphasis on salads where they can appropriately be used; and the danger of keeping vegetables and potatoes hot for prolonged periods on a hot plate.

(b) *Two Combined Canteen Meals for Steel-rollermen*

As a contrast to the shipyard workers, we can now consider the diet of a group of metal workers making steel sheets in a rolling mill. Their meals were arranged in the following way:

Meal 1. Breakfast at 5.30 a.m. (bread, butter, jam, tea).

Meal 2. A canteen "snack" at 8 a.m. (This "snack" usually consisted of porridge with milk, followed by an egg sandwich or a meat sandwich.)

Meal 3. A second canteen meal of bread and jam and tea at 11 a.m.

Meal 4. Dinner at home at 3 p.m. (This was usually a cooked meal of meat, potatoes, vegetables, bread, jam or cheese and tea.)

Meal 5. Tea at 6 p.m. (bread, butter, jam, cake, toast, etc.).

Meal 6. A miscellaneous meal consumed between 9 and 10.30 p.m. (bread and jam or fish and chips, etc. The evening's beer is included as part of this "meal".)

TABLE 24

Typical Nutritional Values of Daily Meals Eaten by a Group of Steel-rollermen

	Food, oz.	Calories.	Protein, g.	Vitamin A, i.u.	Vitamin C, mg.
I. *Breakfast*					
Bread	3	213	7	0	0
Butter	½	105	0	570	0
Jam	½	35	0	0	1
Tea	9	45	1	40	0
		398	8	610	1
II. *Canteen "snack 1"*					
Porridge	10	111	3	0	0
Milk	6	102	5	180	2
Bread	6	426	14	0	0
Margarine	½	109	0	280	0
Cold beef	1¾	156	7	20	0
		904	29	480	2
III. *Canteen "snack 2"*					
Bread	3½	248	8	0	0
Butter	¼	53	0	280	0
Jam	½	35	0	0	1
Tea	9	45	1	40	0
		381	9	320	1
IV. *Dinner*					
Sausages	3	219	9	0	0
Mashed potatoes	6	126	4	0	12
Carrots	2	12	0	3,460	4
Bread	3	213	7	0	0
Margarine	¼	53	0	140	0
Cheese	1	117	7	370	0
Tea	18	90	2	80	0
		830	29	4,050	16
V. *Tea*					
Bread	5	355	12	0	0
Butter	½	105	0	570	0
Jam	½	35	0	0	1
Cake	1	82	2	0	0
Tea	9	35	1	40	0
		612	15	610	1
VI. *Supper*					
Beer	40	400	4	0	0
Bread	6	426	14	0	0
Butter	½	105	0	570	0
Jam	¾	52	0	0	1
Tea	9	35	1	40	0
		1,018	19	610	1
Total day's consumption		4,143	109	6,680	22

Typical meals providing the average nutritional values found to be obtained by these workers are shown in Table 24 with their calculated composition.

This study of the diets of two types of workers brings to light a number of important facts. First, it can be seen how the day's food is split up into six meals, both by the shipbuilders and by the steel workers. Secondly, the shipyard workers' canteen dinner, although it was an excellent hot meal, providing as much as the men could eat at a sitting, contributed fewer calories and less protein, vitamin A and other nutrients not shown as calculations in the table (notably, fat, iron and riboflavin) than did the *two* communal "snacks" which had been specially designed to meet the needs of the steel workers. These needs arose from the fact that their working hours were from 6 a.m. to 2 p.m. and that their working conditions were so hot that they were loth to walk out into the cold to go to the general canteen.

One of the best attributes of a well-cooked hot meal such as that enjoyed by the shipyard workers is the vitamin C it contributes. Without it, the steel workers' diet was deficient in vitamin C. To make "snack" meals nutritionally complete, therefore, one must introduce greenstuff, oranges, tomatoes or other fruit. As Table 18 shows, an ounce of apple contains only 1 mg. of vitamin C, which is not very much (an ounce of strawberries contains 7 mg.); but a good-sized apple may weigh half a pound or so—and that is why, even nowadays, an apple a day may still keep the doctor away.

We have seen that two communal meals during a working shift may on occasion be as valuable as, or more valuable than a single larger meal. The number of meals in the day was the same in both the instances we chose. Now, therefore, let us

consider some of the factors affecting the number of meals a man eats.

The Effect of Shift-timing on the Number of Daily Meals

The timing of working shifts may modify the type of meal best suited to men using a communal canteen. The effect of a change in shift time affecting men's dietary arrangements was strikingly brought out during an investigation of the nutrition of railwaymen unloading waggons at a London goods depot.

The average diet of a group of men working on a particular shift from 6 a.m. to 3 p.m. was made up of five daily meals thus :

(*a*) Breakfast of about 600 calories at 5 a.m.
(*b*) A snack at the canteen at 8 a.m. (about 650 calories).
(*c*) At 1 p.m. a hot dinner was provided at the canteen, but, because they knew that they were leaving work at 3 p.m., the men chose to eat a " snack " instead. This usually consisted of the pudding from the prepared canteen dinner and a glass of beer, the whole amounting to about 550 calories.
(*d*) Their real dinner of meat and vegetables and a sweet or bread and jam was eaten at home at about 4 p.m. It was calculated to supply about 800 calories. This meal was so late that the customary tea meal was squeezed out.
(*e*) The fifth meal of the day was a miscellaneous supper of about 900 calories.

In contrast to this diet, we have that of another group whose work differed from that of the first only in that it did not call for the unloading of an early fish train. The working shift was therefore timed two hours later—from 8 a.m to 5 p.m.

But the effect of this change led to the eating of six meals a day instead of five. The dietary arrangement, therefore, became as follows:

(*a*) Breakfast at 6.30 a.m. (350 calories).
(*b*) Canteen snack at 10 a.m. (750 calories).
(*c*) Canteen dinner at 1 p.m. (700 calories).
(*d*) Canteen snack at 4 p.m. (450 calories).
(*e*) Tea at home at 6 p.m. (800 calories).
(*f*) Supper (450 calories).

The effect of the later working hours was to make the midday full meal at the canteen "fit" the men's needs. The lesson of the earlier shift timing is that the industrial nutritionist must not try to *make* his men eat the meals he provides, whether they "fit" or not. He must instead study the working arrangements of the men he is serving in order to get his meals to fit into their total day's diet.

Practical Considerations Affecting Meal Frequency

All that the science of nutrition has so far been able to tell us about meal frequency is that when men are doing very exhausting physical work they will probably benefit if the level of glucose in their blood is prevented from falling. This can be achieved by the consumption of a mid-shift meal in the morning and in the afternoon, assuming that the shift is worked during the day. The examples we have examined in this chapter have shown that the present custom in heavy industries, such as ship-building, steel-rolling and railway cartage, is for men to eat not five but six meals a day. This is almost certainly good physiological practice and likely to produce the highest degree of efficiency in these more arduous occupations.

The primary scientific reason for frequent meals for heavy workers is the maintenance of the blood-glucose level. Of secondary significance is the bulkiness of the diet needed to provide the energy for heavy work. This factor becomes of increasing importance as the proportion of fat dwindles. In parts of Germany after the collapse of 1945, when the amount of fat in the diet was very low, it was not uncommon to see workers continually gnawing at dry bread. A meal of bread alone containing sufficient calories for their needs would have been too bulky for comfort.

Many heavy workers in Britain—for example, dockers and miners—have been accustomed to eating sandwiches of fat bacon or dripping. These are very rich in energy value. When fatty foods of this nature are not available, an equal number of calories must be provided from some other source. Shortage of fat inevitably makes the substitute item bulkier, since no food contains so high a concentration of calories as fat. In these circumstances it is often sensible to split what was previously one meal, into two.

Conclusions

1. The academic principles of nutritional science can deal with authority when the matter in question is the number of calories and the amounts of the many different nutrients needed by average individuals engaged in different kinds of work *during the course of each complete day*. Although scientific knowledge can provide useful information about the desirable composition of individual meals, its conclusions on this point are less sure.

2. The ideal number of meals for people in different industrial jobs cannot be stated dogmatically. Efficiency and physical well-being may rise for reasons other than

nutritional when an additional meal break is introduced. And since continuous multiplication of meal breaks will soon cause a *reduction* of industrial output, judgment must be exercised.

3. Workers doing very heavy jobs will benefit from frequent meals during their working shift. Six daily meals, of which two or three are eaten at work, are recommended. There is little evidence that workers in light industry have a *nutritional* need for frequent meals.

4. Snack meals may be as important as hot meals, and equal thought needs to be given to their nutritional composition; in particular, the provision of a source of vitamin C must be insured at some time during the day.

5. The timing of the day's work may effect the number of meals a man eats, and hence the nutritional adequacy of his diet. Here, then, is the key to success: *scientific methods can only be applied effectively to industrial feeding if the caterer has a thorough knowledge of the life and habits of the workers in their homes as well as at their jobs.*

Chapter Eight

NUTRITION IN LIGHT INDUSTRY

THE terms "light industry" and "light work" have a meaning, although it is not easy to define exactly what that meaning is. The machining and assembly of small parts would be called light engineering. This work is often, but not always, done by women. Cotton-spinning and other branches of the textile industry are other examples of light work where many of the employees are women. Some occupations in the laundry industry can also be considered to be in this category. Here again many women are employed.

Although we divide light from heavy industry, the separation is not always justified. The heaviest object a ten-stone worker lifts when he carries a spanner to his mate up a ladder is a 140-lb. man. Similarly, a bus conductress who must run up and down stairs twenty times an hour is doing heavy work (see Table 5, p. 19), whereas a heavy press operator, whose work is accomplished by pushing the buttons of an automatic machine, is not.

The principal factors which determine whether work is in fact heavy or light are:

(*a*) The amount of lifting required: the use of a heavy hammer or other tool may be reckoned as lifting.

(*b*) The amount of walking and, particularly, of climbing necessary.

(*c*) Heavy clothing and boots may materially increase the energy output required.

Variation in the Energy Expenditure of Women Working as Cotton-spinners

The variation in the energy requirements of similar types of ostensibly light work is clearly shown in the following account of a study of cotton-spinners carried out in Lancashire in 1944. The first group of women investigated were " card tenters ", " ribbon " and " sliver lap tenters ", " combers " and " drawing-frame " operators, together with an equal number of women working on the " slubbers ", " intermediates " and " rovers ". The work was not hard and consisted for the most part in sitting or standing watching the machines. Occasionally an adjustment had to be made or a bobbin changed. The day's shift was from 7.45 a.m. to 5.30 p.m.

The women's daily meals were : breakfast of bread, butter and tea, sometimes with porridge, at 6.45 a.m. ; a works breakfast at 9 a.m. of buttered toast and tea from the canteen or bread-and-butter or jam carried from home. The third meal, dinner at 12.30 p.m., was a hot meal from the canteen or sandwiches from home. At 3.15 p.m. time was allowed for an afternoon snack. After work, at 6 p.m., tea was eaten, and the local custom was to include fish and chips or meat pudding, often with potato and cabbage and always with bread-and-butter and tea. The sixth meal of the day was a light one, sometimes, indeed, restricted to a cup of cocoa or a glass of stout.

The nutritive value of the average meals eaten by a group of twenty of these women is shown in Table 25.[1]

[1] Pyke, 1944, *Proc. Nutrition Soc.*, 3, 135.

TABLE 25

Average Nutritive Value of the Meals Eaten by a Group of Women Working on Tenters, Drawing-frames and Slubbers, Intermediates and Rovers in a Cotton-mill

	Calories.	Protein, g.	Fat, g.	Calcium, mg.	Iron, mg.
1. Breakfast	280	6	10	120	1
2. Works breakfast	360	10	9	130	1
3. Dinner	600	17	25	230	4
4. Snack	210	4	8	60	1
5. Tea	780	20	32	200	3
6. Supper	230	6	8	130	1
Total daily consumption	2,460	63	92	870	11

	Vit. A, i.u.	Vit. B_1, mg.	Riboflavin, mg.	Niacin, mg.	Vit. C, mg.
1. Breakfast	210	0·18	0·2	0·8	0
2. Works breakfast	220	0·24	0·2	1·3	0
3. Dinner	1,260	0·39	0·3	3·6	16
4. Snack	120	0·07	0·1	0·5	1
5. Tea	510	0·36	0·4	3·0	13
6. Supper	150	0·15	0·2	1·6	0
Total daily consumption	2,470	1·39	1·4	10·8	30

This diet is not perfect—for example, it is low in vitamin A—but it is such that reasonably good nutrition could be supported on it. The calorie figure can probably be assumed to be that needed for the work done by the women eating it.

In the same factory a group of women working at "high-speed cone-winding" were also studied. This work, like the other, could be described as "light". It was, however, very different. "High-speed cone-winding" kept the women on their feet all day walking up and down a row of winding-cones. As threads came to an end or broke, these

women, with great dexterity and quickness, and a substantial expenditure of physical energy, rapidly joined the yarns by means of a small machine which they carried in one hand. The average nutritional value of the six daily meals they ate is shown in Table 26. It can be seen from these figures that these women, working in the same factory as the women of Table 25 and offered the same canteen meals, possessed a requirement for energy approximately 1,000 calories a day greater. The number of people studied in this group was thirty.

TABLE 26

Average Nutritional Value of the Meals Eaten by a Group of Women Engaged in High-speed Cone-winding in a Cotton-mill

	Calories.	Protein, g.	Fat, g.	Calcium, mg.	Iron, mg.
1. Breakfast	530	13	18	190	2
2. Works breakfast	420	14	14	160	3
3. Dinner	940	24	42	220	5
4. Snack	240	6	5	70	1
5. Tea	900	24	45	270	4
6. Supper	400	11	18	210	2
Total daily consumption	3,430	92	145	1,120	17

	Vit. A, i.u.	Vit. B_1, mg.	Riboflavin, mg.	Niacin, mg.	Vit. C, mg.
1. Breakfast	310	0·24	0·2	1·3	1
2. Works breakfast	290	0·29	0·2	1·2	2
3. Dinner	410	0·36	0·4	4·1	14
4. Snack	240	0·12	0·1	0·7	1
5. Tea	880	0·42	0·4	3·3	8
6. Supper	280	0·12	0·2	0·5	1
Total daily consumption	2,410	1·53	1·5	11·1	27

It is interesting to observe that these women, whose work imposed a greater need for energy than that of the group included in Table 25, obtained their additional calories by eating more at each of the six meals of the day. The works management could exert no direct control over the women's breakfast, but purposely restricted the " works breakfast " in order not to take away the women's appetite for dinner. It is questionable whether this was a good plan. For the more active workers the dinner meal of 940 calories at a single sitting was rather bulky. An improvement on the " works breakfast " of buttered toast would have been :

(*a*) more to eat, *e.g.* more toast, bread, rolls or cheese, etc. ;

(*b*) a source of vitamins A and C, *e.g.* tomato or salad sandwich with herring or liver sausage.

Tomato or salad or other source of vitamin A, in which the diet as a whole was deficient, could have been given appropriately, either at the " works breakfast " or at the afternoon snack. As we have mentioned before, salads and fruit and other " protective foods " of like kind tend to be bulky. They are, therefore, better excluded from those meals which are already bulky.

The problems facing the canteen at this particular cotton-mill have a general application. First, they show the need for balance between main meals and so-called subsidiary meals. They also show that different groups of workers using the same canteen may require different amounts of food.

This latter point is shown in even more striking contrast by the consumption of a small group of men employed in the same plant and also fed by the same canteen.

The Influence of Walking on the Energy Output of Light Workers

In this mill, where 300 women were employed, there were also about 100 men engaged in " mule-spinning ". Each of these men was in charge of two rows of bobbins extending 100 feet or more across the full width of the mill. All day long these rows of spinning-reels advanced towards each other across the floor until they were only a foot or two apart. Then, at a quicker pace, the two opposing ranks rolled briskly back until they were separated by 10 yards or more. The men walked continuously backwards and forwards with the machines and up and down the long, constantly moving rows. Their actual work called for skill and dexterity rather than muscular effort, but there was hardly a moment during the day when they could stop walking. Thus their energy requirement reached 4,000 calories daily. The average nutritional value of their meals is shown in Table 27.[1]

This table suggests that the canteen was not providing these men with enough to eat. For them, a larger mid-day meal and larger, or perhaps more frequent, snacks would have avoided the necessity for so massive a meal at tea-time (1,250 calories !). The total day's intake also points another moral : although the actual work was delicate and " light ", the fact that the men were compelled continuously to walk took them out of the " light " into the " heavy " class. The physiological demands of walking are discussed again in more detail on page 156.

The diet of the " mule "-spinners has been discussed at some length as an exception ; but it is an exception representative of a distinct class—the person doing what is thought

[1] Pyke, 1944, *Proc. Nutrition Soc.*, 3, 135.

TABLE 27

Average Nutritional Value of the Meals Eaten by a Group of Men Engaged in "Mule"-spinning in a Cotton-mill

	Calories.	Protein, g.	Fat, g.	Calcium, mg.	Iron, mg.
1. Breakfast	480	13	19	220	2
2. Works breakfast	550	14	16	160	2
3. Dinner	860	20	37	260	4
4. Snack	280	6	12	70	1
5. Tea	1,250	33	53	360	6
6. Supper	610	7	11	130	1
Total daily consumption	4,030	93	148	1,200	16

	Vit. A, i.u.	Vit. B_1, mg.	Riboflavin, mg.	Niacin, mg.	Vit. C, mg.
1. Breakfast	430	0·24	0·3	1·4	0
2. Works breakfast	350	0·33	0·2	1·9	0
3. Dinner	680	0·42	0·4	4·1	14
4. Snack	70	0·06	0·1	0·3	0
5. Tea	760	0·66	0·6	5·2	14
6. Supper	120	0·12	0·4	4·6	3
Total daily consumption	2,410	1·83	2·0	17·5	31

to be light work, but which is really heavy. A group of men doing light engineering in an automobile works, whose diet was also studied in detail, represent a more normal state of affairs. As in previous instances, they were found to be eating six meals a day. The estimated nutritional values of each of these were, however, calculated to be 450 calories, 14 g. of protein and 17 g. of fat for breakfast at 7 a.m.; a 300-calories snack between 9 and 10 a.m.; a hot dinner between 12 and 1 p.m., providing 850 calories, 30 g. of protein, 30 g. of fat and 30% of the day's total of 35 mg. of vitamin C. This was followed by a 250-lorieca snack at

4 p.m.; a substantial tea at home between 6 and 7 p.m., estimated at 750 calories, 20 g. of protein, 25 g. of fat and the remainder of the day's vitamin C; and miscellaneous supper items amounting on the average for the whole group studied to 200 calories. The total average daily intake was thus 2,800 calories, 85 g. of protein and 95 g. of fat. The calcium and iron were calculated as 0·75 g. and 16 mg. and the vitamins A, B_1, riboflavin and niacin as 2,250 i.u., 1·6 mg., 2·8 mg. and 12 mg. respectively. This is more nearly what can be expected for men doing light engineering in the normal conditions of industrial life.

Differences between Individuals

Up till now we have talked only about the *average nutritional requirements of groups of people* and about the average amounts of foods they eat and the average quantities of different nutrients they get from them. We are fully justified in paying so much attention to this aspect of the science of nutrition; scientific information is most complete in this direction and, above all, the industrial nutritionist is primarily concerned with large numbers of people. Therefore the " recommended nutrient allowances " of Table 1 summarising the requirements of different types of people for calories, proteins, minerals and vitamins, or such modifications of them as the increase in scientific knowledge may demand, must remain the keystone of our discussions.

But although knowledge of the *average needs of the normal consumer* is well established and is of great importance to the industrial caterer, what suits " Charlie Brown " may be very different from the average. In other words, although the principles of nutrition are always of general application, individual behaviour may vary widely within the average. In fact, the saying that " one man's meat is another man's

poison " has a place in our present discussions. Both Jack Sprat and Mrs. Sprat are always to be found among the industrial workers for whose needs the industrial caterer must provide.

We all know that there are tall, thin people and round, fat people and big, square, muscular people. These are three quite distinct types, and no amount of physical training or dieting will ever change one type into another. Professor Sheldon published in 1940 a systematic study [1] of the many factors which differentiate one kind of person from another. Because he realised that people differ from each other by an infinite number of small gradations, he established a classification by means of which anyone could be placed in one or other of seventy-six different physical categories. At one end of the scale was the " endomorph ", a round-faced, round-bodied person who tended in later life more and more closely to resemble a balloon. At the other end of the scale was the tall, thin, drawn-out person with a receding chin and an Adam's apple. This type he called the " ectomorph ". In the middle came the " mesomorph "—a thick, square, hairy, muscular person. The " mesomorph " is the type epitomised by Tarzan or Sandow, the person illustrated in the physical culture magazines.

It is important for the nutritionist to remember that these radical differences in type exist. The more deeply they are studied the more profound they appear to be. Susceptibility to disease, psychological outlook and physical efficiency as a working machine are all affected to a greater or lesser degree by the type of physique with which a person happens to be born. The potential importance of these considerations to the nutritionist is immediately apparent.

[1] Sheldon, 1940, " The Varieties of Human Physique ", Harper, New York.

The magnitude of the effect of physique on dietary requirements is demonstrated by only one of Professor Sheldon's observations taken at random. He showed, for example, that people with certain types of physique always possess a basal metabolic rate (that is to say, a basal need for calories) twenty points higher than the average.

The exact relationship between nutritional intake, the efficiency with which individuals do work and their body type is not known. The "endomorph"—the rounded person who tends to fatness—has a larger, longer digestive tract than the tall, thin "ectomorph". All that can be said about diet, however, is that some individuals need very much more food than others. The tremendous extent of the differences between people is shown by the figures in Table 28. These records[1] were obtained by careful weighing for a week of everything eaten by middle-class men of approximately equal activity, whose diet was not restricted in any way. Similar wide variations have been found in studies of industrial workers engaged on the same jobs in an engineering plant.[2]

Measuring the Nutritional Value of Diets

We have been discussing the nutritional values of the meals eaten by different types of workers in some of the varying circumstances of industrial life. This must be done if we are to know whether or not what they eat is adequate for their needs. But although a general impression of the dietary adequacy of any pattern of meals can be fairly easily reached, precise figures are very difficult to obtain.

For example, the amounts of calories and nutrients available to a gang of men who eat all their meals in a hostel can be calculated from the record of the food consumed during

[1] Widdowson, 1936, *J. Hygiene*, 36, 269. [2] Pyke, unpublished.

Table 28

Individual Daily Nutrient Intake of 39 Men between the Ages of 20 and 40

Occupation.	Calories.	Protein, g.	Fat, g.	Calcium, g.	Iron, mg.
Teacher	1,653	57	69	0·77	0·1
Research worker	2,072	74	96	0·46	11·2
Doctor	2,161	69	79	0·53	11·4
Student	2,215	73	115	0·43	14·0
Student	2,347	94	87	0·78	15·8
Student	2,356	94	132	0·39	19·8
Engineer	2,381	89	89	0·55	14·5
Student	2,402	71	90	0·47	10·1
Research worker	2,439	75	91	0·49	12·8
Doctor	2,483	105	123	0·80	20·3
Doctor	2,578	78	106	0·97	16·6
Clerk	2,640	90	112	1·05	13·8
Teacher	2,659	83	135	0·48	15·0
Stoker	2,765	62	121	0·40	10·2
Mechanic	2,838	118	134	0·63	18·1
Student	2,893	84	105	0·85	13·1
Student	2,920	95	124	1·26	15·5
Stoker	2,934	113	118	0·79	19·3
Student	2,960	92	116	0·67	16·6
Clerk	2,975	86	131	1·04	14·4
Doctor	2,987	120	155	0·98	19·1
Dentist	3,019	88	163	0·66	13·3
Research worker	3,050	105	146	1·02	17·1
Student	3,099	91	127	0·84	17·8
Carpenter	3,133	88	137	0·88	21·2
Student	3,288	92	128	1·06	14·1
Lab. technician	3,335	116	139	1·27	18·0
Commercial traveller	3,342	97	130	0·66	13·9
Lab. technician	3,355	107	147	1·14	18·1
Research worker	3,468	113	174	1·40	19·8
Research worker	3,480	128	164	0·81	27·8
Clerk	3,527	99	161	0·89	17·1
Lab. technician	3,706	110	162	1·58	19·4
Lab. technician	3,743	103	169	0·67	18·8
Research worker	3,960	138	164	1·27	25·5
Student	4,100	135	208	1·96	17·2
Student	4,259	128	203	0·93	19·4
Student	4,447	93	215	0·83	18·5
Electrician	4,815	167	199	1·96	28·5

any given period. Even in the specially favourable circumstances of the complete diet being supplied by the institution canteen, however, a number of careful precautions must be taken by anyone who wishes to collect records from which nutritional calculations can safely be made.

Among these are the following:

(*a*) *All* foods, including locally purchased vegetables, canned goods taken from store, home-rendered fat, etc., must be included in the record.

(*b*) A careful allowance must be made for waste of all sorts.

(*c*) Special circumstances, such as the losses of nutrients due to unsuitable cooking equipment, must be accounted for.

(*d*) Notice must be taken of ancillary meals and beverages consumed outside the institution and parcels or gifts sent in.

In normal circumstances, where the people live at home and come out to the factory daily, *a precise estimate of the nutrient intake can seldom be made.* When physiological investigations are undertaken, volunteers must be chosen who are prepared to weigh all their food and drink for at least a week. It is difficult to the verge of impossibility to find more than a very few normal workers who are prepared to undertake this laborious procedure and who have sufficient skill to execute such a study accurately. However, it can be done, and the figures in Table 28 were obtained by Dr. Widdowson in this manner. Figures in other Tables were obtained from weekly records kept by the people surveyed, checked each day by the researcher, and the quantities of each food recorded assessed by matching with weighed amounts of similar articles.

The Nutrient Composition of some Model Menus

A diet for an industrial worker can be made up in an infinite number of ways, and, provided the principles of nutrition and the factors such as a reasonable meal frequency and a reasonable degree of attractiveness are maintained, many varieties of food combinations may be equally satisfactory. There are numerous publications which give recipes and menus to suit different tastes and customs or to make use of a limited availability of food. The nutritional significance of a menu can be determined by the method of calculation already described. In Table 29 is shown the calculated nutritional value of three menus which have been recommended [1] as suitable for works canteens serving a light industry.

Table 30 shows the nutritional value of three types of mid-shift snacks which are of a nature often met with in light industry.

We can now summarise the principles upon which the nutrition of workers in light industries must be based.

1. Because a man or woman works in what might be considered to be a light industry, it does not automatically imply that his or her physical effort is any less than that of a worker in a heavy industry. Furthermore, within a single industry there may be groups of workers whose energy requirements differ widely.
2. It is current practice in many light industries to provide three meals during the course of the working shift. This custom is probably based on physiological need. It usually implies that each worker

[1] Practical Canteen Catering, Industrial Welfare Society, 2nd Ed. March, 1946, London.

TABLE 29

Nutrient Content of Three Menus for Canteen Dinners

	Oz.	Calories.	Protein, g.	Fat, g.	Calcium, mg.	Iron, mg.	Vit. A, i.u.	Vit. B_1, mg.	Riboflavin, mg.	Niacin, mg.	Vit. C, mg.
I. Roast Beef :											
Beef	3·2	339	19·2	29·1	6	4·2	40	0·07	0·14	4·5	0
Gravy :											
Flour	0·2	19	0·7	0·1	8	0·1	0	0·7	0·01	0·1	0
Yorkshire Pudding :											
Flour	1·0	97	3·3	0·4	42	0·6	0	0·08	0·04	0·5	0
Dried Egg	0·1	16	1·3	1·2	6	0·3	80	0·01	0·04	0	0
Milk	1·0	18	1·0	1·0	34	0	40	0·01	0·04	0	0
Dripping	0·1	25	0	2·8	0	0	0	0	0	0	0
Potatoes, roast	9·3	111	3·2	0	11	1·1	0	0·18	0·06	1·8	16
Greens : cabbage	5·0	35	2·0	0	90	1·5	420	0·11	0·08	0·4	35
Fruit Fool :											
Apples	2·0	34	0·2	0	2	0·2	0	0·01	0	0·2	2
Beet	1·0	12	0·5	0	12	0·2	10	0·02	0·02	0·1	1
Sugar	0·2	22	0	0	0	0	0	0	0	0	0
Milk	2·0	36	1·9	2·0	68	0·1	80	0·02	0·09	0·1	0
Custard : custard powder	0·2	20	0	0	2	0	0	0	0	0·1	0
Total		784	33·3	36·4	281	8·3	670	0·53	0·52	7·8	54
II. Rabbit Stew :											
Rabbit	3·2	122	18·2	5·4	10	2·2	0	0·03	0·45	5·8	0
Beans	1·3	33	2·2	0	21	0·9	0	0·02	0·01	0·3	1
Onions	1·6	10	0·5	0	14	0·2	0	0·01	0·01	0	2
Flour	0·2	19	0·7	0·1	8	0·1	0	0·02	0·01	0·1	0
Potatoes, boiled	12·0	252	7·2	0	24	2·4	0	0·41	0·13	4·1	36
Greens : cabbage	5·0	35	2·0	0	90	1·5	420	0·11	0·08	0·4	35
Summer Pudding :											
Plums	2·0	38	0·2	0	6	0·8	40	0·01	0·02	0·4	2
Sugar	0·3	32	0	0	0	0	0	0	0	0	0
Bread	2·0	144	5·0	0·6	62	0·9	0	0·13	0·06	0·7	0
Milk	1·0	18	0·9	1·0	34	0	40	0·01	0·04	0	0
Total		703	36·9	7·1	269	9·0	500	0·75	0·81	11·8	76
III. Fish and Cheese Pie :											
Fish	1·6	37	8·2	0·5	6	0·2	0	0·02	0·06	1·4	0
Potatoes	8·0	168	4·8	0	16	1·6	0	0·27	0·09	2·7	0 *
Cheese	1·0	116	7·1	9·8	230	0·2	370	0·01	0·14	0·1	0
Flour	0·1	10	0·3	0·1	4	0·1	0	0·01	0	0	0
Potatoes, boiled	12·0	252	7·2	0	24	2·4	0	0·41	0·13	4·1	36
Greens : cabbage	5·0	35	2·0	0	90	1·5	420	0·11	0·08	0·4	35
Jam Sponge :											
Flour	1·6	155	5·3	0·7	67	1·0	0	0·13	0 06	0·8	0
Dried Egg	0·1	16	1·3	1·2	6	0·3	80	0·01	0·04	0	0
Margarine	0·5	109	0	12·1	0	0	0	0	0	0	0
Sugar	0·3	32	0	0	0	0	0	0	0	0	0
Milk	0·8	14	0·8	0·8	27	0	30	0·01	0·04	0	0
Jam	0 8	57	0	0	2	0	0	0	0	0	5
Total		1001	37·0	25·2	472	7·3	900	0·98	0·64	9·5	76

* Complete destruction when twice cooked.

TABLE 30

Nutrient Content of Three Types of Mid-shift Snacks

	oz.	Calories.	Protein, g.	Fat, g.	Calcium, mg.	Iron, mg.	Vit. A, i.u.	Vit. B_1, mg.	Riboflavin, mg.	Niacin, mg.	Vit. C, mg.
I. A slice of cake:											
Flour	1·2	116	4·0	0·5	50	0·7	0	0·10	0·05	0·6	0
Margarine	0·5	109	0	12·1	0	0	0	0	0	0	0
Sugar	0·5	54	0	0	0	0	0	0	0	0	0
Dried Egg	0·1	16	1·3	1·2	6	0·3	80	0·01	0·04	0	0
Dried Fruit	0·5	33	0·1	0	8	0·2	0	0	0	0	0
Total		328	5·4	13·8	64	1·2	80	0·11	0·09	0·6	0
II. A sandwich:											
Bread	3·0	216	7·2	0·9	48	1·5	0	0·15	0·09	0·9	0
Margarine	0·9	109	0	12·1	0	0	280	0	0	0	0
Salmon	1·0	48	5·7	2·8	85	0·4	71	0·01	0·06	1·8	0
Watercress	0·5	2	0·4	0	31	0·2	237	0·01	0·01	0·2	8
Total		375	13·3	15·8	164	2·1	588	0·17	0·16	2·9	8
III. A Cornish pasty:											
Flour	3·0	291	9·9	1·2	126	1·8	0	0·24	0·12	1·5	0
Fat	1·0	253	0	28·1	0	0	0	0	0	0	0
Meat	1·5	120	6·3	12·0	4	1·6	21	0·03	0·10	1·9	0
Potato	2·0	42	1·2	0	4	0·4	0	0·06	0·04	0·6	3
Total		706	17·4	41·3	134	3·8	21	0·33	0·16	4·0	3

eats six meals during the day. The nutritional contribution from the so-called subsidiary meals is often equal to that of the main midday meal, and there seems no reason why such subsidiary meals should not each be made approximately equal to the midday dinner.

3. The individuals in light industry, like those elsewhere, may have individual requirements which differ widely from each other. There is thus a general principle to be followed; although nutritional standards of *average* requirements can be drawn up, any system of catering must be sufficiently flexible to allow for the needs of those people who differ most markedly from the average.

Chapter Nine

HOT AND HEAVY WORK AND THE EFFECT OF FUMES ON NUTRITIONAL NEEDS

JUST as there are many men employed in light industry whose work is arduous, so are there men working in heavy industries whose labour demands little muscular effort. In general, however, heavy industrial work calls for an increased expenditure of calories. Certain heavy industries also entail that men work in hot conditions or exposed to a combination of heat and fumes. Heat produces an additional requirement for salt which will be discussed in detail later. Sometimes, although by no means always, fumes of certain kinds give rise to special nutritional needs. Although special foods, and notably milk, may supply these special requirements, the demand for milk for all sorts of industries has often been made on quite unconvincing grounds. Even where fumes or other toxic factors produce a clear nutritional claim, it is to-day considered to be better wherever possible to remove the fumes rather than to try to deal with their possible effect on the body by nutritional means after a condition of hazard has already arisen.

The physiological factors governing the nutritional requirements of people called upon to exert heavy muscular effort have been discussed in the earlier chapters of this book. The practical problem for people interested in industrial nutrition is the interpretation of these scientific principles in terms of

meals. The academic literature states, as was shown in Table 1, that whereas " physically active " work requires 3,000 calories and 1·5 mg. of vitamin B_1, " with heavy work " a man expends 4,500 calories, with other nutrients in proportion. The practical difficulty is to know, without carrying out complex physiological tests, whether a particular factory job is " physically active " work, a job " with heavy work " or something in between.

Practical Classification of a Heavy Worker

During World War II, the Ministry of Food drew up a list of industries to which food could be provided in canteens at what was termed the Category A scale. These industries were selected with the guidance of the trades unions and the Ministry of Labour as being those in which the work was heavy. The list of industries, given in Table 31, was not drawn up on a strictly physiological basis. Within any industry a certain number of jobs will always be found

TABLE 31

Industries Singled Out as being Heavy Work

1. Brick, tile and cement manufacture.
2. Building, constructional and excavational work.
3. Mining and quarrying.
4. Docks.
5. Gas works and coke ovens.
6. Heavy engineering and steel constructional work.
7. Iron and steel works, and metal extraction.
8. Rolling and tube mills.
9. Shipbuilding and repairing.
10. Tinplate works.
11. Agriculture and forestry.
12. Certain cold stores.
13. Coal distributive trades.
14. Light metal foundries.
15. Tanning of hides.
16. Manufacture of sanitary ware, sanitary, fireclay and salt glazed pipes.
17. Sections of plywood manufacturing industry handling heavy logs.
18. Abrasive industries.

demanding only a small expenditure of physical effort. The list, however, is of some interest as giving in general terms the rough-and-ready classification of what experienced practical people consider heavy work to be.

The scientific literature contains comparatively few observations of the nutritional requirements of men in different industries, although, as has been shown in Chapter Two, the demands per hour of a number of activities have been studied. This information makes it possible to construct a composite picture of a day's work, and hence to deduce the day's needs. A number of examples were given in Chapter Two.

How can the nutritional requirements of a heavy worker most effectively be provided? Since the fundamental need is for calories, the nutrient most clearly in demand in a quantity greater than that obtained by less arduously engaged workers is *fat*.

(1) Thus, *increased fat* will enable a man to increase his calorie consumption without unduly increasing the bulk of his diet. Sugar will also exert a similar effect.

(2) Another reasonable recommendation is that *fairly frequent meals* be provided. Table 24, on page 99, is worthy of study on this account. This table gave part of the results of a survey of the food consumption of steel-workers rolling steel sheets whose daily intake exceeded 4,000 calories. The work of these men was of a very arduous and exhausting nature. During the shift two meals, specially designed to meet their needs and to suit their tastes, were provided for them. These meals were, furthermore, given at the actual place of work. The men were not required to go from the hot atmosphere of the

mill to a canteen. It is not uncommon to find workers refusing to accept meals when it is necessary for them to go from a hot to a colder environment to obtain them.

Nutritional Demands of Hot Work

Hard work in an industrial plant often has to be done in a hot environment and in an atmosphere containing fumes. The broad principles which govern heavy work as such apply also to heavy work done at high temperatures. That is to say, the need for calories and B-vitamins is increased, and with it the need for fat and sugar and frequent meals; the need for other nutrients is, with the one exception of salt, unchanged. Protein is discussed further below. Of course, if the heat is such that the men do not work so hard, their calorie requirement will be correspondingly reduced.

Whenever the body temperature becomes markedly raised, however, there is an increase in metabolic rate[1] and, in consequence, the expenditure of calories becomes increased. Little evidence is available as to whether the conditions of industry are sufficiently severe materially to increase the body temperature, and thus the metabolism and the calorie requirement.

There is a well-known tendency for people living in the tropics to avoid high-protein diets, which exert a high *specific dynamic action*, and to choose instead a diet richer in carbohydrates. Specific dynamic action is the property of meat and other protein foods which causes part of the calories they provide to be dissipated as heat; it was discussed on page 56. It was then pointed out that during the course of hot work, meat and other sources of protein should not be eaten, as they tend to make the worker still hotter. Sugar

[1] Bazett, 1927, *Physiol. Rev.*, 7, 531.

and other carbohydrates devoid of an admixture of protein are best given instead.

Fats are found to be less acceptable in hot climates ; but we are discussing hot work in a temperate climate, which is a different matter.

Salt

The body temperature in a hot environment is maintained by the evaporation of sweat from the skin at the constant normal level of about 98·4° F., at which it must remain for physiological well-being. Sweat consists of water containing a low concentration of potassium and sodium chloride (common salt). The concentration of chloride tends to increase if sweating is prolonged.[1] Normally, most people eat in their food substantially more salt than their bodies need. The excess is excreted through the kidneys in the urine. If the excess of salt in the body diminishes, the amount lost from the body in the urine can be regulated by the kidney, and a urine can be passed which is almost salt-free. The skin does not possess this power, and when sweating is continuous there is a steady loss of salt from the body.

Muscle-cramps due to salt deficiency are well known as an effect of exposure to heat for a long period, particularly when heavy work, such as stoking, is being done. The cramps may be accompanied by headache, extreme tiredness or lassitude, vomiting and diarrhœa. Men who drink large quantities of water *during the time they are working in heat*, and who consequently sweat profusely, are particularly liable to suffer these symptoms.

Zinc-smelting in horizontal retorts is one of the hottest

[1] Adolph, 1923, *Amer. J. Physiol.*, 65, 419.

and most exhausting jobs to be found in industry. During the course of a day I observed that experienced men in this occupation drank moderately *during* their shift, but immediately their work was finished they consumed up to a gallon or more of beer at a sitting.

The effect of drinking excessively during the course of hot work is to induce very heavy sweating and a correspondingly large loss of salt. Men who drink moderately obtain sufficient liquid to enable them to sweat sufficiently to regulate their body temperature, although a degree of dehydration, shown by loss in weight during the shift, usually occurs. The dehydration and loss of weight are made good at the end of the working period. The ideal to be aimed at is to balance the water lost by sweat during the progress of the work by the amount of liquid drunk.

Haldane [1] in 1905 made the observations upon which recommendations are now generally given that men doing hot work should eat plenty of salt. Moss [2] later reported that miners in hot pits ate more salt with their food than did other individuals. It is generally known to-day that if a drink containing 0·2% of salt is consumed instead of water, cramps are unlikely to occur. In certain hot industries there are various preferences for drinks other than plain salt and water: salt and barley water and salted beer are two. Both these have the merit that besides making good losses from the body of salt and of water, they supply calories from a source other than protein. For example, the zinc-smelters mentioned above who drank eight pints of beer after their work between about 1 p.m. and the time the public-houses closed at 2.30 p.m. had obtained approximately 1,600 calories from the beer before they sat down to their dinners.

[1] Haldane, 1905, *J. Hygiene*, 5, 494.
[2] Moss, 1923, *Proc. Roy. Soc.*, B. 95, 181.

The Effect of Fumes and Certain Toxic Substances on Nutritional Requirements

Hot work is often done in a bad atmosphere contaminated by fumes. Fumes—for example, smoke or steam—do not of themselves affect nutritional needs. Certain types of fumes and dust do exert a noxious effect, however, and in some circumstances the harmful effect of these agents can be countered by nutritional means. *Nevertheless, it cannot be too strongly emphasised that the appropriate way of dealing with such circumstances is to remove the fumes or to avoid their production altogether, rather than to seek protection by dietary measures.*

With the above proviso in mind, it is perhaps useful briefly to review the nutritional requirements specifically raised by a few of the commoner types of potentially harmful industrial substances.

There is a widespread belief that *milk* is a specific for all sorts of toxic conditions. Milk, as has already been mentioned, is a very remarkable food. A pint of milk provides substantial quantities of calcium, of animal protein, of fat and of vitamin A and riboflavin. It can therefore very often make adequate a diet which without it is deficient in one or other of these nutrients. This means that milk is a useful food, and not that it will necessarily ward off some special danger. We have already seen in many of the tables in earlier chapters that an adequate diet can be provided from the foods which are commonly chosen by industrial workers, and which were available during the years from 1940 to 1947.

Lead Workers

Historically and because large numbers of heavy workers are involved, lead poisoning has occupied a prominent place

in industrial nutrition. But the incidence of lead poisoning among workmen has fallen dramatically in recent years. Whereas 1,250 cases were notified in 1899, only 100 were reported in 1938![1] Some of the workers among whom lead poisoning is occasionally seen to-day[2] are those using red lead in stencilling glass before cutting and grinding; those using lead for stencilling silk; among telephone and telegraph workers; in type-setters; among those cutting tobacco on lead plates in cigar manufacture; in workers exposed to lead dust in automobile body plants and in the manufacture of lead-bronze bearings; among solderers; metal finishers and welders in automobile plants; people setting stained glass in lead; those exposed to the volatilisation of lead from painted metal in cutting structural steel with an oxy-acetylene flame; and among soldiers using field kitchens in which leaded petrol is burned.

Lead obtains access to the body primarily through the lungs as dust or fumes. The proper protection, therefore, is good ventilation. Lead exerts a negligible effect on men who are merely handling the metal. When lead has been absorbed into the body, either through the lungs, through the stomach or, less commonly, through the skin, it behaves rather like calcium, and Lederer and Bing[3] in 1940 showed that the absorption of lead was diminished by the addition of calcium to the diet. Since *milk* is one of the best dietary sources of calcium, it is one of the foods which can appropriately be used to contribute calcium to the diet of lead workers.

The list of metals used in industry which may be harmful to people working with them is large. Among the most

[1] Hunter, 1943, *Quart. J. Med. N.S.*, **12**, 185.
[2] Fairhall, 1945, *Physiol. Rev.*, **26**, 182.
[3] Lederer and Bing, 1940, *J. Amer. Med. Ass.*, 114, 2457.

common are mercury, cadmium, manganese and chromium. Against all these the only sure protection is good factory management and ventilation. Similarly with lead, it can be said that no nutritional procedure offers protection, and that milk is of use only as a vehicle for adding calcium.

Workers Handling Chloroform, T.N.T., etc.

A number of toxic fumes to be met with in industry affect the liver. Among these the most notorious are chloroform and related substances and trinitrotoluene (T.N.T.). It has recently been shown that a diet high in protein, and particularly in protein rich in the amino-acid *methionine*, exerts a protective effect against this type of liver damage.[1] Once again it can be argued that *milk* is a food rich in protein, and therefore suitable for people working under conditions in which they may be exposed to these industrial dangers. Against this we have the observations reported in previous chapters showing that the normal types of diets eaten by work-people in the U.K. provide ample margins of protein over the requirement of, say, 70 g. daily. For example, the shipyard workers and the steel-rollermen described in Tables 23 and 24 were found to be eating 107 g. and 109 g. of protein daily. The men in the railway goods yard (page 101) were obtaining 112 g. to 116 g. daily and the "mule" spinners 93 g. The requirement of mixed protein is for those in health who are eating normal food, largely independent of such considerations as the supply of single amino-acids; the composition of the proteins in different foods balance each other, so that a mixture from several foods has an adequate biological value.[2] We can therefore argue once again

[1] Himsworth, 1944–45, *Proc. Roy. Soc. Med.*, 38, 10.
[2] Macrae, Henry and Kon, 1943, *Biochem. J.*, 37, 225.

that for people exposed to the hazard of T.N.T., chloroform, etc.

(*a*) a reasonable diet will provide adequate protein to maintain the power of resistance of the liver;
(*b*) additional milk cannot be expected to give a higher degree of immunity if the normal diet is already satisfactory, and
(*c*) that it is better to remove the toxic fumes before they can attack the worker's health rather than to try to bolster up his resistance against them.

Vitamin C as a Protective Nutrient

A number of dietary measures, other than the provision of milk, have been recommended on nutritional grounds to combat various sorts of industrial conditions. A high consumption of vitamin C has been recommended as a protection against benzol and other aromatic hydrocarbons.[1, 2] Vitamin C has also been shown to be present in low concentrations in the blood of people exposed to T.N.T., and a high vitamin C intake has in consequence been suggested as a protection against this substance.[3] The justice of these recommendations, however, is not yet completely clear. What is apparent, is that the importance of providing the full nutritional requirements for the normal nutrition of the people doing their work in an industrial plant becomes doubly important when there is the possibility that they may be asked to work under hot conditions possibly contaminated with harmful fumes.

[1] Seyfried, 1942, *Arch f. Geworbepath ir Gewerbehyg.*, 11, 588.
[2] Meyer, 1937, *J. Amer. Med. Ass.*, 108, 911.
[3] Noro, 1941, *Acta Med. Scand. suffl.*, 120, 95.

Conclusions

Let us now try to collect together the practical lessons taught by the scientific assessment of the nutritional needs of heavy workers.

(a) *When men are doing heavy work they require a diet rich in calories.* Heavy work involves the lifting of heavy weights or handling tools requiring the expenditure of strong muscular effort. The lifting of the body in walking about and in climbing will often constitute heavy work. On the other hand, just because a man is dealing with a large or heavy machine it does not mean automatically that his work is heavy. For example, the man machining the rotor for a power-station generator may do little more tham manipulate a micrometer. A light meal will be more suitable for such a worker.

(*b*) In order that a high calorie diet for a heavy worker may not be unduly bulky and may be palatable, 30% *or more of the total calories should be derived from fat.* If, therefore, the total energy requirement is 4,000 calories, the daily fat intake from all sources must be at least 135 g. ($4\frac{3}{4}$ oz.), since this amount provides $135 \times 9 = 1{,}215$ calories. This does *not* mean that there must be $4\frac{3}{4}$ oz. of butter, margarine and cooking fat in each day's diet. It means rather that the total fat, from meat, from bacon, from milk and, indeed, from all foods, plus the "visible" fats should provide this amount. Sugar is also a useful nutrient for adding calories to the diet of a heavy worker without increasing its bulk.

(*c*) *Frequent meals* are useful for heavy workers in order to enable them to obtain conveniently their substantial nutritional requirements. In many parts of Britain, men eat six meals a day. It is probably sound industrial practice to provide at least two or, where circumstances permit, three

meals during the normal working hours. One of these may profitably be a hot cooked meal. Equal attention, however, needs to be paid to the nutritional value of so-called snacks or mid-shift meals, and it may well be that these should provide amounts of nutrients equal to those contained by the " main " meal.

(*d*) Men working under *hot conditions* need additional *salt*. They should not drink excessively while they are working; but moderate amounts of a drink containing 0·2% of salt and, perhaps, carbohydrate such as sugar and barley, are useful. Protein possesses a *specific dynamic action*, the effect of which is to raise the body temperature. Hence, meat and other protein foods should not be given in large quantity *during* working hours.

(*e*) In certain circumstances diet may give some limited protection against toxic substances to be met with in industry. Milk and other foods which contain substantial amounts of calcium may have a preventive effect against lead, and a high protein consumption may raise a man's resistance to the harmful effects of chloroform, benzol or T.N.T. No nutritional measures, however, can provide sure protection, and the only sound policy is the avoidance of danger by effective ventilation or closed processes or other means. A properly balanced diet is essential for all industrial workers for nutritional health and physical efficiency. The absence of a nutritionally adequate diet may, however, be the cause of greater harm where men are exposed to toxic hazards.

(*f*) The differences in the mechanical efficiency with which individual men and women do work are very great. It therefore follows that even when the *average* requirements of a group of people doing a specific job are high, there are certain individuals whose requirements will be materially less, just as there will be others whose needs are more. This

brings us back again to the cardinal principle of industrial nutrition as applied to heavy workers or to any other category. It is this: *industrial workers are individuals*, and the caterer who can break down his or her numbers in such a way that the woman serving the meal can give "Tommy Jones" just the kind of helping he likes will not only be conforming to the laws of good catering, but to those of physiology as well.

Chapter Ten

THE COAL-MINER

THERE are many different types of work comprised in the general term " coal-mining ". There are surface workers, engineers and other tradesmen, as well as the men doing a multiplicity of different jobs underground. Just as it takes a dozen supporting men to keep one soldier in the firing line, so it requires as many in support of the men on the coal-face who actually get the coal.

The work of coal-miners employed underground may affect their nutritional requirements in a number of ways. First, the physical labour demanded of them is hard, and it must sometimes be done in hot and humid surroundings and under cramped conditions. Secondly, the nature of their work affects the type of meals which can be eaten during working hours. And thirdly, the shifts into which the miners' day is divided may make it necessary for meals to be eaten at unconventional times.

Two serious studies have been made within recent years of the nutritional requirements of British miners. In 1924 a committee of the Medical Research Council [1] undertook to investigate the problem. The Committee attempted no direct measurements either of the daily output of physical work of the miner or of his calorie and nutritional intake.

[1] Medical Research Council, 1924. Sp. Rept. Ser., 87.

They reviewed the literature of muscular energetics, however, and reached the following conclusions.

Medical Research Council's Report of 1924

The basis of their first argument rested on the statement, for which they quoted no specific authority, that, "it has been found by repeated experiments on subjects tested on ergometers, or work-measuring machines, which can measure exactly the amount of external work done by the subject, that the mechanical efficiency with which the work is done is in general about 25 per cent. This means that only one-quarter of the energy liberated from food can be converted into external work." The committee them selected what they considered to be the best value for the average output of mechanical work produced by an "ordinary human worker" in an eight-hours working day. The figure they chose was between 80,000 and 90,000 kilogrammetres, or about 200 calories.[1] They then made the following estimate of the daily calorie requirement of a coal miner:

8 hours sleep at 62 calories per hour	= 496
8 hours work at 68 calories per hour plus 200 calories × 4 (to allow for the 25% efficiency of work)	= 1,344
8 hours free time at basal plus 175%	= 952
	2,792 calories

The Committee themselves were not entirely satisfied with this somewhat speculative method of assessment, and they made a second estimate in which they assumed the existence of a larger miner with a basal metabolism of 72 calories an hour, a work output of 240 instead of 200 calories in a seven-hour day, and an efficiency of 20%, and not 25%.

[1] Work can be calculated in the following terms: 1 calorie = 426·6 kilogrammetres = 3,086 foot-pounds.

These assumptions gave a hypothetical requirement made up as follows :

8 hours sleep at basal rate less 10%	= 518
7 hours work at 72 calories basal plus 240 × 5	= 1,704
9 hours free time at 115·2 calories per hour	= 1,037
	3,259

No direct measurement was made by the Medical Research Council's committee of the food consumption of miners. A number of records were collected in different parts of the country, however, of all the food used by miners' families during a week. The assumption was then made that the miner himself possessed a " man value " of 1 ; his wife was rated at 0·83 and his children at decreasing fractions according to age down to 0·5 for those under two years old. This assumption, that the man actually ate from the family meals proportionally in accordance with his calorie requirement, begged the question, since it was the object of the study to find out what that requirement was.

Professor Moss' Investigations 1923–24 and 1935–36

A more realistic series of studies of the nutritional requirement of coal-miners was carried out by Professor Moss, Professor of Coal-Mining at Birmingham University.[1, 2] With some little trouble, Professor Moss was able to collect from sixty men working in seven different mines a weighed record of all that they ate and drank during a period of from seven to ten days. The results of this survey are shown in Table 32.

In the next part of his study Professor Moss attempted to measure directly the amount of work done by the men he

[1] Moss, 1923–24, *Proc. Roy. Soc.*, B. 95, 181.
[2] Moss, 1935–36, *J. Inst. Civil Engineers*, 3, 354.

TABLE 32

Average Dietary Intake of Coal-miners (*Moss* 1923–24)

District.	No. of men.	Avg. underground temperature, ° F.	Avg. daily calorie intake.	Avg. total liquid drunk, qrts.*
Pendleton . .	6	99	5,925	11
Pendlebury .	6	88	5,114	9·2
Hamstead . .	10	79	4,644	8·5
Forest of Dean .	12	68	4,293	3·6
Derbyshire .	8	66	4,211	4·4
Yorkshire . . .	8	59	4,472	4·6
S. Wales . .	12	55	4,320	3·7

* An imperial pint = 0·57 litre.

Percentage of Calories Derived from Different Foods

Bread.	Butter, Marg., Dripping.	Meat.	Bacon and Ham.	Potato.	Pudding.	Cake.	Cheese.
32·6	15·5	13·8	9·6	5·5	1·4	0·8	3·1
32·1	11·4	14·1	16·3	6·6	1·1	2·2	2·6
31·9	7·8	15·8	18·6	7·2	1·0	1·3	5·7
33·4	11·1	11·9	6·6	9·3	5·6	4·5	4·3
34·2	7·8	10·9	9·9	5·5	9·9	3·9	1·5
37·5	15·0	7·3	4·0	5·4	8·7	3·5	0·4
31·2	17·4	11·0	11·2	3·5	2·1	12·1	2·0

was studying. Individuals who were in training as members of rescue teams, and who were in consequence accustomed to working while wearing breathing apparatus, were used. During the course of their work in the pit the volume of the air they breathed was measured by connecting the breathing apparatus to a meter. By first analysing the air breathed in and then analysing a sample of the air breathed out, the unit amount of oxygen used in a measured period of time was calculated. The sample of expired air was collected by

turning a cock and allowing the air to pass into a " Douglas " bag of 100 litres for one, two or three minutes. This procedure was used to measure the rate of oxygen absorption for each type of work done during the day—for example, when cutting coal, when loading coal into a wagon, when erecting props and timbers, when resting, etc. The amount of oxygen absorbed gives a measure of the amount of fuel oxidised within the body, and hence of the amount of heat or energy set free by metabolism (see p. 16). About 1 litre of oxygen is known to be absorbed for each 5 calories [1] of energy released.

The conclusions reached after a detailed study of the miner's day was that his energy output was :

	Calories.
Work in pit : 5½ hrs. work, 1½ hrs. walking, ½ hr. eating .	2,800
Walking to and from pit : 1 hr. at 3 m.p.h. . . .	300
Leisure : 7½ hrs.	850
Sleep : 8 hrs.	540
	4,490
Recalculated to a 5½ working day week : average per day .	4,072

It will be seen that Moss' work, although carried out on comparatively few individuals, was a *direct* study, first, of what miners actually ate when they were doing their day's work, and, secondly, of the actual output of energy demanded by the different types of physical exertion which go to make up their working day.

In order to estimate the approximate output of mechanical work, and hence the mechanical efficiency of the miner, each man on whom experiments were performed in the mine came to the laboratory of Birmingham University. Here his height and weight when stripped were obtained. He was then made to pedal a bicycle ergometer, a machine designed to

[1] Kilogram-calories.

measure mechanical work, and at the same time his oxygen consumption for four or five different rates of work was measured. By this means the amount of work each man did (measured in terms of calories) could be compared with the calorie value of the food he burnt while doing it (calculated from the amount of oxygen he absorbed), and from these two figures his *mechanical efficiency* (in the engineering sense) during the performance of different coal-mining activities could be calculated. By this means, the efficiency of work production was found to be approximately 25%, as had been estimated by the Medical Research Council Committee, but only if the work was being done by the man in an erect position. The reduction in efficiency for other conditions of work is shown in Table 33.

TABLE 33

The Mechanical Efficiency of Coal-miners Working in Different Postures, Average of Eight Men (Moss, 1935–36)

Posture.	Efficiency of work, %.
1. The erect position	25
2. The half-stoop, corresponding to a loss of body height of 20%	20 (12–28)
3. The full stoop, corresponding to a loss of body height of 40%	9 (1 –12)
4. The all-fours position, corresponding to a loss of height of 50%	7 (2 –10)

On the basis of the above figures, Professor Moss estimated that the *average* mechanical efficiency of a coal-miner was 15%.

In discussing these researches at the time they were presented to the Institute of Civil Engineers in London in 1935, Hanssen made the cogent comment that it was uneconomic

to use a man as a source of direct mechanical power. He pointed out that when a man exerted a manual output of $\frac{1}{8}$th horse-power, for which he received the then wage of 1*s.* 3*d.* an hour, a horse-power cost at least 10*s.* If the miner was working in constrained conditions, the cost of 1 h.p. could rise to 28*s.* 9*d.*, whereas the same power could be obtained by mechanical means for a penny.

Two final aspects of Professor Moss' work are worth discussing before we review our other evidence of the food requirement of the miner. It is interesting, first, to study in Table 34 the different oxygen consumption and energy output of the different activities which the miner is obliged to do.

TABLE 34

Energy Requirements of the Different Occupations of the Underground Miner

Occupation.	Oxygen consumption per minute, litres.	Calories * per hour.	Foot-pounds † per minute.
Resting	0·54	162	—
Coal-getting	1·55	465	3,943
Loading	1·60	480	4,177
Timbering	1·35	405	3,394
Packing	1·33	400	3,567
Drilling	1·42	426	3,423
Ripping	1·52	456	4,350
Miscellaneous	1·29	387	3,490

* Assuming that 1 litre of oxygen is equivalent to 5 calories of energy.
† Based on the oxygen consumption found at different levels of work output on the bicycle ergometer.

It was estimated that a miner spends approximately 27% of his working shift taking rest-pauses.

Secondly, it is worth recording that the calorie consumption in the hot pits studied by Moss was greater than in the

cooler pits (see Table 32). This may be due to an increase in basal metabolism occurring at the higher temperature, to which reference was made on page 123 in Chapter Nine. It was found that in a pit at a temperature of 98° to 100° F., and a wet-bulb temperature of 85° F., the amount of sweat lost during a shift might reach 18·75 lb. The average weight loss from sweat during the shift was 13 lb.

When we come to summarise the available information on the physiological needs of coal-miners, all that we can say is that the Medical Research Council in 1924, basing their conclusions on the literature, calculated that their energy requirement was 3,259 calories. Ten years later, Professor Moss, after studying a number of small groups of miners in considerable detail, concluded that the requirements for underground work were approximately 4,500 calories daily for a six-day week. This is equivalent to approximately 4,000 calories daily for a five-and-a-half-day week.

Studies of the Nutrient Intake of Coal-miners in 1943–44

A series of inquiries into the nutritional value of the diets actually eaten by miners in a number of different coalfields was made in the winter of 1943–44. The average diets set out in Tables 35 to 40 are based on groups usually of ten men. We have seen in previous chapters that individual variations may be very wide. The figures shown, while they depend on too few observations to lay claim to general validity, give at least examples of estimates of the nutrients consumed by a number of groups studied under the practical conditions of mining.

At the outset it is important to appreciate that the amount of work done in different mines varies. Where mechanisation in a mine is extensive, the physical demands on the men

are less. In some mines it is necessary for men to walk long distances up and down steep " drifts ", in other mines the roads are level, or there are underground trams to transport the miners to and from their work. A second factor is that different dietary customs exist in different localities. Some, but not all of these, are due to the timing of the shifts.

Underground Miners Eating Four Meals a Day

In certain mines the underground workers are accustomed to a diet made up of four meals. Let us review the conditions found in two different pits where this type of daily arrangement existed.

In Leicestershire, for example, in a dry, gas-free, highly mechanised mine in which the coal-face and the pit bottom were both at the same level and the width of coal-seam about 5 ft., thus allowing reasonable working head-room, men on the 7 a.m. to 2.30 p.m. shift ate :

(1) a breakfast of an average of 600 calories, 20 g. protein and 20 g. fat at 5.30 a.m. ;
(2) a " snap " of cheese, bacon, meat or jam sandwiches providing 1,300 calories, 50 g. protein and 45 g. fat at 11 a.m. ;
(3) dinner at home at 3 p.m., providing an average of 950 calories, 25 g. protein and 25 g. fat and the whole of the day's intake of vitamin C, and
(4) supper at about 8 p.m. supplying an average of 700 calories, 25 g. of fat and 25 g. of protein.

The total daily intake of these men supplied 3,550 calories, 120 g. protein, 115 g. fat, approximately 1·5 g. and 24 mg. of calcium and iron ; 2,800 i.u. of vitamin A ; 2·7 mg., 1·6 mg. and 14 mg. of vitamin B_1, riboflavin and niacin, and the

comparatively substantial amount of 50 mg. of vitamin C principally from a generous consumption of potatoes.

In the Lancashire coalfield a contrasting mine was very deep and hot, with a temperature of 100° F. at the coal-face (78° F. wet bulb). The seam was only 2 ft. 3 in. high, and the men consequently had to crawl. The effect of this environment was that, although a similar four-meal dietary pattern was adopted, the mid-shift " snap " contributed an average of only 250 calories, and in consequence the men ate more for dinner and supper. The total diet at this mine provided 4,050 calories. The small " snap " caused the men to eat a very large dinner later (average 1,630 calories, 50 g. protein and 60 g. fat). The need for calories, however, unconsciously led to a distaste for green vegetables, which are bulky and of low calorific value, with the result that the total diet was seriously deficient in vitamin A. It contained, in fact, only approximately 1,000 i.u. daily. If food had been more plentiful in 1943, when this study was made, an increased consumption of butter, eggs and liver could have been recommended.

Underground Miners Eating Five Meals a Day

The pattern of four meals a day is by no means universal among miners. Three groups of workers, again in different parts of Britain, can be cited to show three separate variations of a diet of five meals a day.

In South Wales a group of coal-face workers on a shift from 7 a.m. to 2.30 p.m. were studied who ate each day :

(1) breakfast at 5.30 a.m. (average 650 calories) ;
(2) a substantial " snap " underground at 10.30 a.m. (average 1,200 calories) ;

(3) a quick meal at the pit-head canteen at 3 p.m. (average 400 calories);
(4) dinner at home at 4 p.m. (average 1,100 calories and almost the whole day's supply of vitamin C), and
(5) supper at about 8.30 p.m. (average 950 calories).

A point of interest about this arrangement was that the reason why the men obtained five meals a day, and not four, was because the train which took them along the valley from the mine to their homes waited for the last man of the shift to be wound out of the pit. Most of the men had therefore to wait, and the delay enabled them to buy a snack or to eat a hot meal at the canteen before they went home. Attempts are sometimes made to delay transport on purpose to provide the opportunity for men to eat a meal at their canteen. These efforts, however, are almost always unpopular, and consequently defeat their own ends.

A second example of a five-meal dietary pattern was seen in a Yorkshire mine in which the day shift extended from 6 a.m. to 1.30 p.m. This timing led to the consumption of:

(1) breakfast of 650 calories at 4.30 a.m.;
(2) a " snap " of 1,100 calories at 9.30 a.m.;
(3) dinner of 750 calories at 3 p.m.;
(4) tea of 650 calories at 6 p.m.; and
(5) supper of 500 calories at 9.30 p.m.

This convenient and sensible arrangement was possible because the shift time enabled the men's meals to fit into the dietary pattern of their families. Dinner could be eaten comfortably at home at 3 p.m., and still allow the miner to share the customary tea-meal at 6 p.m.

The final example shows a striking contrast. In Durham,

in order to conform to the working plan of the mine, the "fore" shift, extending from 4 a.m. to 11 a.m., necessitated the consumption of

(1) breakfast at 2.30 a.m. (at this unhandy time few of the group of those studied were inclined to eat much, and the average energy value of the meal was 320 calories);
(2) the next meal, a "bait" at 8 a.m., provided 650 calories;
(3) dinner at 11.30 a.m. provided 1,370 calories;
(4) tea at 5 p.m. 750 calories, and
(5) supper at 9.30 p.m. contributed 1,250 calories to an average daily total of 4,250 calories, 129 g. protein, 147 g. fat, 1·2 g. calcium, 26 mg. iron, only 1,800 i.u. of vitamin A, 2·5 mg. vitamin B_1, 1·8 mg. riboflavin, 21 mg. niacin and 38 mg. vitamin C.

Underground Miners Eating Six Meals a Day

A logical development taking account of the miner's high energy requirements and of his need underground for meals not too bulky to hamper work, which must often be done in a crouching posture, is the division of the food he eats underground into two parts, and hence the consumption of a diet consisting of six daily meals. This dietary pattern was found among coal-miners in a pit in Fifeshire in Scotland.

The day shift here was from 7 a.m. to 2.30 p.m.

(1) Among the group of men studied, the average breakfast eaten at about 5.30 a.m. provided 450 calories.
(2) Although the day's shift officially began at 7 a.m., the men had to walk more than a mile from the pit bottom to the coal-face before they were able to

start work, and it was on arrival at the coal-face at about 7.30 a.m. that they ate an " unofficial piece " providing an average of 300 calories.

(3) The " official piece " eaten at 10 a.m. was the day's third meal, contributing an average of 650 calories.

(4) The men ate their dinner at home at 3.30 p.m., when they acquired 1,150 calories, 45 g. protein, 35 g. fat and 90% of the day's vitamin C.

(5) The fifth meal was tea at 6 p.m., which amounted to 550 calories on average.

(6) The dietary pattern was completed by a supper at about 9.30 p.m., supplying 700 calories.

These men ate an average of 3,800 calories a day, 140 g. protein, 110 g. fat, 1·9 g. calcium, and 30 mg. iron. The calculated vitamin intake was 2,300 i.u. of vitamin A (too little); 2·7 mg., 2·1 mg. and 20 mg. of vitamin B_1, riboflavin and niacin, and 35 mg. of vitamin C.

The contrasting dietary patterns of the different groups of miners discussed here are shown in summary in Table 35.

The table illustrates several of the complexities which make an understanding of coal-miners' diets so difficult. Thus we see groups of underground workers eating four meals a day, five meals a day and six meals a day. These differing arrangements may be due to shift timing. For simplicity, only morning or fore-shifts have been included. Afternoon, or back-shifts, and night-shifts, which are discussed in Chapter Twelve, lead to still further complications.

Besides shift times, the times at which transport arrives and leaves affect men's eating habits. Other factors are, of course, the nature of the canteen equipment and practical features, such as the distance of the canteen from the pit-head or bath-house.

TABLE 35

Varieties of Dietary Pattern Found among British Underground Coal-miners Working Day-time Shifts

Approximate meal-times.	4 *Daily Meals.*				5 *Daily Meals.*				6 *Daily Meals.*			
	Shift 7 a.m.–2.30 p.m.				Shift 7 a.m.–2.30 p.m.		Shift 6 a.m.–1.30 p.m.		Shift 4 a.m.–11 a.m.		Shift 7 a.m.–2.30 p.m.	
	Calories.	Vit. C, mg.	Calories.	Vit. C, mg.	Calories.	Vit. C, mg.	Calories.	Vit. C, mg.	Calories.	Vit. C, mg.	Calories.	Vit. C, mg.
02.30	—	—	—	—	—	—	—	—	320	0	—	—
04.30	—	—	—	—	—	—	650	0	—	—	—	—
05.30	600	0	900	—	650	0	—	—	—	—	450	0
07.30	—	—	—	—	—	—	—	—	560	0	300	0
09.30	—	—	—	—	—	—	1,100	0	—	—	650	0
11.00	1,300	0	250*	—	1,200	0	—	—	1,370	27	—	—
15.00	950	50	1,650	—	400	0	750	20	—	—	1,150	29
16.00	—	—	—	—	1,100	27	—	—	—	—	—	—
17.00	—	—	—	—	—	—	—	—	750	0	—	—
18.00	—	—	—	—	950	6	650	0	—	—	550	0
20.00	700	0	1,250	—	—	—	—	—	1,250	11	—	—
21.30	—	—	—	—	—	—	500	0	—	—	700	4
Daily calorie intake .	3,550		4,050		4,300		3,650		4,250		3,800	

* "Snap" eaten under hot and cramped conditions.

A further point, which is of somewhat more direct nutritional interest, is the human element.

Dietary Prejudices : Cheese

Miners have strong prejudices, which vary from one part of the country to another. There is no obvious physiological reason why the amounts of nutrients provided by the mid-shift sandwiches should voluntarily be varied between one district and another. Yet this is the case : the variation is often related to the distribution of a strong and equally mysterious prejudice against cheese. Some figures are shown in Table 36.

TABLE 36

A Comparison of the Calorific Value of the Food Eaten Underground by Coal-miners in Different Parts of Britain [1]

Coalfield.	Average energy value of mid-shift meal, calories.	Proportion of day's requirement, %.	Avg. daily cheese consumption, oz.
Leicestershire .	1,100	28	1·9
South Wales .	1,100	28	1·8
Fifeshire . .	950	24	1·1
Yorkshire . .	840	22	0·9
Lancashire . .	650	17	0·2
Durham . .	610	16	0·2

The Nutritional Value of the Diets Eaten by Surface Workers

We have already seen that the energy demands of different types of underground work may differ widely. Coal-face workers, however, are not the only people to be considered by those responsible for the nutrition of coal-miners. There are a large number of men who are miners and who work at a coal-mine but who do not dig coal. Many do not even go underground. The latter, while often sharing the special provisions arranged for the underground worker, are not subject to the peculiar conditions of underground work which render those provisions necessary.

Work on the surface is often hard, although it is not always so. For example, the sorting of coal on the " screens " may be almost sedentary and may, in fact, be done by cripples or young boys. At the other extreme, heavy " tubs " and massive steel pit props may need to be handled, and may demand the most arduous of labour. When an estimate was made after interviewing men at five separate mines in as

[1] Pyke, 1945, *Proc. Nutrition Soc.*, 3, 134.

many coalfields, it was calculated that the average diet provided from 2,550 calories—equivalent to that consumed by light, sedentary workers—to 4,300 calories, which would satisfy the needs of heavy workers. Mechanics, carpenters, blacksmiths and other tradesmen employed at three separate mines were estimated to be eating diets providing 3,500 calories daily.

Conclusions

Application of Nutritional Principles to the Practical Problems of Feeding Coal-miners

The most important of the practical findings which have emerged from the scientific studies of the coal-miner's nutritional needs are these:

1. Coal-mining is heavy work, but it is no heavier than many other occupations, and less arduous than some. The average energy expenditure of, say, 4,000 calories a day for a miner working a five-and-a-half-day week is about the same as that of a steel worker or a builder's labourer, and is probably less than that of a logger in the woods.
2. There are a number of circumstances which may increase the arduousness of a coal-miner's job, and hence increase his need for food. Work done in a stooping posture demands more energy; and work done under hot conditions sufficient to raise the body's temperature will also increase the calorie requirement.
3. The shift hours to which many miners are subjected complicate the times of their meals and the daily number of meals. To the outside observer, the timing of certain shifts—say, from 4 a.m. to 11 a.m.—

appears little short of barbarous. The wonder is that the men are as adaptable as they are, and contrive to eat reasonably satisfactory diets even under these circumstances.

4. The most significant practical feature of the coal-miner's occupation from the point of view of the nutritionist is that the face workers cannot come to a canteen or restaurant, nor can they go home, for the meal they eat midway through their working day.

These four factors can guide the industrial nutritionist to this extent. First, he or she must provide high-calorie meals. If these are cooked meals they must contain adequate fat, or food such as meat (including ham) which contains fat. Sugar and flour—as pastry or dumplings, for example—are also useful. The miner needs a balanced diet containing vitamin A and vitamin C and the rest; but vitamins must not be introduced at the expense of calories. Vitamin C, for example, can often be provided better in fried potatoes rather than in salad.

If the meals are sandwiches (snacks, snaps, bait; call them what you will), the provision of calories is automatic. The "balancing" of the meal—that is, the supplying of vitamins—then becomes the problem. Table 35 showed that of the four, five or six meals miners eat, no more than two provided any material amount of vitamin C. Hence, an orange or an apple is a good thing to include in the miner's snap tin, and tomato or watercress or chopped cabbage can usefully be put into the sandwiches for vitamin C and vitamin A, as well as ham and cheese and jam and dripping for calories and protein.

Conditions vary from mine to mine, and the only sound scientific advice that can be given to the caterer is—be

scientific. Study the conditions at the particular pit and the dietary customs of the miner. Remember that every meal is nutritionally important; whether it be served at four o'clock in the morning or at midday, whether it is a hot dinner or a snap, each must fit into the pattern which makes up the day's diet. Finally, let it be remembered that each miner is an individual. The work of many is very arduous, of others is not so; but because he works in dirty surroundings and eats meals at unconventional hours, there is *no excuse* for serving him in a frousy, half-lit canteen and providing warmed-up meals cooked twelve hours before.

Chapter Eleven

THE OUTDOOR WORKER

Of all the different workers in the modern world, who are those whose work is the heaviest? This is a question which it is difficult to answer, since there are a number of factors other than physiology which decide whether a job is exhausting or not. On strictly physiological grounds, however, it is reasonable to grade heavy work as proportional to the physical output of calories it demands. On this basis, such people as steel-workers, zinc-smelters and coal-miners are heavy workers; there are, however, certain outdoor workers who do the heaviest work of all. The reason for this is that in outdoor work a man must more frequently than in indoor jobs move *himself* about. Secondly, in cold weather, no matter what other physical work he may do, he must first lift and carry the heavy clothes and substantial boots he wears.

One clean gum-boot weighs $3\frac{1}{2}$ lb. A man with a 3-foot stride walking for a mile in gum-boots and raising his feet 6 inches (half a foot) high at each stride will perform $1{,}760 \times \frac{1}{2} \times 3\frac{1}{2} = 3{,}080$ ft.-lb. of work by merely lifting his boots. 3,080 ft.-lb. is almost exactly 1 calorie of work; the efficiency of the body is, say, 15%, so that 1 calorie of work needs for its production 7 calories from food. If the man in gum-boots is a ploughman, whose muddy boots have doubled in weight and who walks ten miles between

8 a.m. and noon, the energy he must expend *solely to move his boots about* amounts to $10 \times 2 \times 7$—*i.e.* 140 calories in half a day. The four hours' walking of itself calls for an expenditure of some 800 calories, so that it can be seen that a tax of almost 18% has been imposed on the performance of this work merely because the ploughman is wearing gum-boots. And we have not yet considered the work of manipulating the plough. Is it to be wondered that outdoor work makes a man hungry!

The Food Requirements of Lumbermen

The heaviest industrial work for which records are available is logging. This is an outdoor job for which men wear heavy clothes, walk about on muddy or snowy ground and do hard physical work. Logging companies in America provide their men with their whole diet, and have acquired experience of the amounts of food which they must supply if the men are to be kept contented and in full production. In the spring of 1943 the U.S. War Food Administration[1] conducted a study in a number of camps. Figures were obtained of the amounts of food supplied to the camps. The nutritional value of these supplies is not strictly equivalent to the physiological intake of the men, since a considerable margin must be allowed for waste; nevertheless, they show the order of magnitude of the high nutritional demands required for this type of work. (Table 37.)

Woods and Mansfield[2] studied the diet of fifty Maine lumbermen actively engaged in cutting logs. The average daily food consumption during six days provided 164 g. of protein, 388 g. of fat and 982 g. of carbohydrates, supplying

[1] Alpert, Lusby and Goodhart, quoted in "Nutrition in Industry", 1946, I.L.O., Montreal.

[2] Woods and Mansfield, 1904, U.S. Dept. Ag. Exp. Sta., Bull. 149.

an energy value of 8,083 calories daily. The greatest amount of work of which a man has ever been shown experimentally to be capable was 9,300 calories in sixteen hours. Thus if the Maine lumbermen were actually eating the diet recorded by Woods and Mansfield, they could claim to be undergoing exertion almost equal to Atwater's experimental cyclist who expended 9,300 calories on a bicycle ergometer.

TABLE 37

Daily Food Supplied to American Lumbermen and its Nutritional Value

Food Supply	oz./man/day.	*Nutritional Value*	
Meat, fish, poultry	21	Calories	6,425
Eggs	5	Protein, g.	205
Milk and milk products	36	Fat, g.	292
Butter	2·4	Calcium, g.	1·8
Other fat	1·2	Iron, mg.	35
Cheese	0·8	Vitamin A, i.u.	16,000
Cereals	15	Vitamin B_1, mg.	4·87
Legumes	1·3	Riboflavin, mg.	5·12
Sugar and syrup	9	Niacin, mg.	44·5
Green vegetables	6	Vitamin C, mg.	133
Tomatoes	1·2		
Citrus fruit	0·4		
Potatoes	16		
Other vegetables	3		
Fruit	15		
Dried fruit	0·8		

The very large nutritional requirements of American and Canadian lumbermen are frequently quoted as examples of the needs of the heaviest type of work. It is unlikely, however, that under British conditions there are many men to be found whose calorie intake reaches 6,000 daily.

In February, 1944, I was able to carry out a survey of the nutrient intake of eleven men who were working in Northumberland felling trees and cutting them up for pit props. These men spent each day from 8.30 a.m. to 5 p.m. in the

woods or at the sawmill. Their occupations included the cutting of logs with cross-cut saws, the loading and unloading of timbers on to lorries, stacking timber and running the logs through the circular saws which cut them into props. They ate a substantial breakfast of porridge, bacon or fish and fried bread in their hostel at about 8 a.m., and a cooked dinner at 5.30 p.m., after their return from work. Their last meal of bread-and-cheese with jam and butter was eaten at 8 p.m. They usually divided the food they took with them into the woods into three portions. The dietary pattern and the nutritional value of the day's food consumption are shown in Table 38.

TABLE 38

Average Nutritional Value of the Daily Diet Eaten by British Loggers

	Calories.	Protein, g.	Fat, g.	Calcium, g.	Iron, mg.	Vit. A, i.u.	Vit. B_1 mg.	Riboflavin, mg.	Niacin, mg.	Vit. C, mg.
8 a.m. Breakfast	750	22	31	0·3	3	360	0·51	0·70	4·2	5
10 a.m. Bait .	430	10	19	0·1	3	280	0·21	0·14	1·4	0
12.30 p.m. Bait .	900	23	44	0·2	5	590	0·45	0·31	4·6	0
3 p.m. Bait .	420	12	20	0·2	2	510	0·18	0·21	1·3	0
5.30 p.m. Dinner .	1,270	48	47	0·2	7	290	0·81	0·70	9·2	30
8 p.m. Supper *	270	19	24	0·4	2	710	0·27	1·03	13·9	0
Total daily intake .	4,650	134	185	1·4	22	2,740	2·43	3·09	34·6	35

* Including beer drunk afterwards.

Some Physiological Factors Affecting Outdoor Workers

The men doing this work were experienced at their tasks, and they did not feel that they were working hard. On the other hand, the men engaged in the steel-rolling mill, whose nutritional intake, as shown in Table 24 on page 99, provided 4,150 calories daily, felt, and justifiably, that their work was extremely arduous. The outdoor worker uses the large

muscle-groups of the body, notably those of the legs and trunk. In doing so he performs a large amount of mechanical work, and his energy requirement consequently becomes very great. The industrial worker inside a factory usually stands in one place and uses the smaller muscles of his arms and hands. It has been shown that the work capacity of a muscle is directly dependent on its cross-section.[1] Hence work well within the capacity of the great leg and back-muscle groups will expend more calories of energy than exhausting effort by the smaller muscles of the body.

Our calculation that the wearing of a pair of heavy boots may of itself increase the energy expenditure by 280 calories was based on purely theoretical considerations. Some direct observations made during World War II by Drs. Johnson and Kark[2] are of considerable interest, and throw further light on the problem.

Johnson and Kark studied the amounts of food needed to victual Allied troops operating in different parts of the world. In the desert and in moist tropical areas, where the men wore light clothing, the average food consumption ranged from 3,100 to 3,500 calories; in temperate areas the rations consumed were equivalent to from 3,500 to 4,000 calories a day; and in the arctic, consumption varied from 4,000 to 5,000 calories. These differences cannot be attributed solely to the work involved in moving about in clothing of different degrees of cumbersomeness; but there is no doubt that this factor was one of major significance. The classical text-books of nutrition assert that calorie expenditure is not markedly different under hot and under cold conditions, since the insulating effect of clothing maintains the constancy of the actual environment of the body. This conclusion is

[1] Szakall, 1944, *Arbeitsphysiol*, 13, 9.
[2] Johnson and Kark, 1947, *Science*, 105, 378.

based, however, on the assumption that the same amount of work is being done. This, as we have seen, is not so. And it is the outdoor worker, of all others, who is most likely to be hampered by heavy clothing.

Some of Johnson and Kark's results are summarised in Table 39.

TABLE 39

The Average Daily Calorie Consumption of Troops Operating under Differing Climatic Conditions

	Local mean temperature, ° F.	Calories per man per day.
I. *Desert ; moist tropics*	95	3,100
	85	3,200
	—	3,400
	80	3,500
	70	3,400
II. *Temperate areas*	65	3,500
		3,600
	60	3,900
		4,000
	55	3,700
		4,100
	40	3,700
		3,800
III. *Arctic areas*	20	4,000
		4,100
	10	4,500
	0	4,400
	−5	4,700
	−25	5,000

The Energy Expended in Walking

Much of the total daily requirement of outdoor workers, as we have said, is often derived from the necessity for walking. A League of Nations Technical Commission[1] in

[1] L. of N. Pub. II, *Econ and Finance*, 1936, II, B. 4.

1936 defined light work as that calling for up to 75 calories per hour, moderate work as that demanding from 75 to 150 calories per hour, hard work as that needing from 150 to 300 and very hard work as needing the expenditure of 300 calories per hour or more. The average energy demands of slow walking (2·6 miles per hour) are 115 calories—*i.e.* " moderate work ", in which category house-painting and metal-working also fall. For walking moderately fast (3·75 miles an hour), 215 calories are expended. This of itself is " hard work ", in which classification blacksmithing and rivetting are also included. Very fast walking requires an output of 565 calories an hour. This is " very hard work ", which exceeds wood-sawing and stone-mason's work in activity.[1]

It is easy to understand from these figures how it comes about that it can be estimated that many people in outdoor occupations are likely to have the highest nutritional requirements of all industrial workers.

The significance of walking as the cause for a high energy demand has been fully recognised, and much study has been given to the factors influencing the muscular efficiency with which walking can be carried out in differing circumstances.

One of the most thorough investigations was made by Atzler and Herbert in 1927.[2] These workers studied the mechanical cost of walking as affected by : (*a*) the number of steps per minute, (*b*) the length of stride and (*c*) the consequent speed per hour. The results for a man weighing 70 kg. (154 lb.) were as follows :

The most economical way of walking is with a stride of about 2 feet (58·7 cms.) at a rate of 87·5 steps a minute. This gives a speed of 2 miles an hour (51·4 metres a minute).

[1] Orr and Leitch, 1937–38, *Nutrition Abs. and Rev.*, 7, 509.
[2] Atzler and Herbert, 1927, *Pfluger's Arch. Biochem. Physiol.*, 215, 291.

The energy expended in walking in this way is 56 calories per mile. A short stride of 18 inches (45 cms.) at a slower pace of seventy-five steps a minute, giving a speed of 1·2 miles an hour, calls for an energy output of 59 calories a mile; the energy expenditure of the same stride, but at a rate of 100 steps a minute, giving 1·6 miles an hour, costs the same energy output of 59 calories per mile, whereas a more rapid rate of 150 steps a minute increases the cost to 83 calories per mile for a speed of 2·4 miles an hour. This same speed is attained slightly more economically by doubling the length of stride to 3 feet and halving the number of steps per minute. The cost of attaining 2·4 miles an hour in this way is 80 calories per mile.

The 3-foot stride, which at seventy-five steps a minute (2·4 miles an hour) requires 80 calories a mile, calls for less energy—*i.e.* 72 calories per mile—when the number of steps a minute is increased to ninety (3·2 miles an hour). When the rapidity of the same length of stride is increased to 150 steps per minute, however, and the speed consequently quickened to 4·9 miles an hour, the energy expenditure rises once more to a figure of 92 calories a mile.

These figures demonstrate in quantitative scientific terms what is well known in practice: that it is tiring to walk at a pace slower, just as it is tiring to walk at a pace faster than the "natural" speed. Or, put in a different way, it can be said that there is a certain speed and stride at which it is most economical in calories to walk.

Not all outdoor work involves a great deal of walking. For example, dock workers work out of doors. There appears to have been no scientific study made of the physiological demands of their work. However, the daily task of a stevedore shifting cargo from the hold of a ship involves a heavy expenditure of muscular energy. All dock workers

were classified as heavy workers in the war-time Table 23.

A docker lifts many heavy sacks or packages on to the sling of a crane ; a bricklayer's labourer, on the other hand, besides lifting loads of bricks, has *himself* to lift many times if he spends his day climbing up and down a ladder.

Similarly a bus conductress in a double-decker bus expends a great deal of energy climbing up and down stairs.

Conclusions

The principles to be followed in feeding outdoor workers are the following :

(*a*) Outdoor workers frequently expend more energy than indoor industrial workers, even though, because their work is often done with the great muscle-groups of the legs and trunk, they may appear to be exhausting themselves less. Consequently, the outdoor worker must be provided with sufficiently substantial meals to supply adequate calories for his needs.

(*b*) Because of their high energy requirements, outdoor workers must be given their diet in a form sufficiently compact for them to be able conveniently to eat it. That is to say, it must contain an adequate supply of fat and foods, such as meat, containing fat, and of sugar and other concentrated sources of calories. There is a good physiological basis for the preference of dockers for sandwiches of fatty ham and for the liking of farm labourers for bread and cheese.

Chapter Twelve

FEEDING THE NIGHT SHIFT

Nutritional Principles Apply to Everyone

THE scientific principles of nutrition apply to all groups of people. A moderately active man must obtain 3,000 calories or thereabouts every day, if he is an average person, if he is to be able to perform his day's work. A woman weighing 9 stone, equivalent to 57 kilos, requires 57 g. of protein daily whether she is an Englishwoman or a Finn. Similarly, a deficiency of calcium or of iron or of one of the other minerals needed for health will cause inefficiency and disease if it is not made good by the foods composing the day's meals. And finally, absence of vitamin A will if it is sufficiently prolonged cause a specific affectation of the skin and produce night blindness; shortage of B-vitamins also gives rise to symptoms of the skin, of the mouth and tongue and, in countries where the shortage is severe, it produces the potentially fatal diseases of beri-beri and pellagra; while absence of the vitamin C of fruit and fresh vegetables was for generations the major obstacle limiting exploration and the colonisation of new lands.

Nutrition, to which all of us are subject whether we like it or not, is a *quantitative* science. It is not good enough to say: "my boiled potatoes contain vitamin C". The important matter is: how much vitamin C do they contain? If a man eats less than 10 mg. of vitamin C (that is about

1/3000th of an ounce) daily he may in the end show signs of scurvy. Then his gums will become foul, and will bleed readily. He will develop bruises for no apparent reason, and old scars long healed will tend to break open again. As the amount of potatoes, fruit and vegetables he eats rises, these signs will die away, until when his consumption reaches 30 mg. he will be safe from this deficiency disease, and when his consumption reaches 50 to 75 mg. of vitamin C daily, no further increase can possibly lead to any improvement in health. Similar statements can be made about each of the other nutrients.

A heavy responsibility rests on the industrial caterer, since communal meals, by contributing to the nutrition of the worker, also contribute to his health. Let us see how this is so by considering what Dr. T. Moore of Cambridge has called the six stages of nutrition.

Stages of Nutrition and Malnutrition

The first stage of nutrition, if it can so be described, is starvation and famine. This is the ultimate degree of nutritional deficiency. The second stage is that in which diseases, such as scurvy, rickets, beri-beri and pellagra, which are directly due to bad diet, are found commonly to occur. Then, at the third stage we have a population, like that in parts of Germany and Austria in 1945 and 1946, in which, while there is no obvious disease, the people are thin and underweight and incapable of doing a good day's work. The fourth stage is perhaps where some of us are now. We are quite well. We have no obvious diseases of malnutrition, but many of us possess health and physique capable of improvement by a better diet. This is the real nutritional problem with which the caterer is confronted. For by his

efforts adolescent workers, and many men and women as well, and above all, night workers, may be moved up from the fourth stage of nutrition to the fifth. The fifth stage is the target: optimum nutrition such that no improvement in diet would lead to improvement in health. And for completeness we must mention Dr. Moore's sixth stage of nutrition. This is the stage of hypernutrition or obesity.

Diversity of Diets

We must accept that all groups of workers have rigid nutritional requirements, varying in proportion to the activity of their labour, but nevertheless always in conformity with scientific principles from which we cannot escape. Individuals may differ from each other for a number of reasons, but this does not affect the basic significance of nutrition when applied to groups.

We require certain unalterable amounts of calories, proteins, vitamins and minerals, but we do not eat these nutrients as such; we eat food. And, moreover, the food we eat is divided into meals.

Local customs are often rigid, and food likes and dislikes are frequently strongly held. There is no reason why a good diet should not conform to local custom or satisfy popular tastes. Steak-and-kidney pudding with a good helping of potatoes and sprouts, followed by Stilton cheese and celery, is probably as perfectly balanced a meal nutritionally as could be designed. Equally, a salmon salad with tomatoes and a couple of rolls and butter is a good meal.

An adequate diet can be constructed in an infinitely large number of ways and from a wide selection of foods. Furthermore, the number and type of meals into which the day's food consumption is divided can also be varied within wide

limits. The only essential is that the total nutritional needs for the day should be provided.

Let us therefore now consider the special nutritional needs of night workers, which are the subject of our present discussion, and see in what way they differ from those of other workers.

Nutritional Needs of Night Workers

It is sometimes thought that men who work at night need lighter meals than those who work by day. The amount of food a man needs during the twenty-four hours of the day depends on the length of time he sleeps, the amount of exercise he takes and the physical demands of his work. There is no evidence to suggest that men working by night do less arduous work, or that their hours of sleep are longer, or that they take less exercise than men doing day work. If this is true, it must certainly follow that they need as much food. If a well-cooked meal of roast beef and vegetables followed by pudding is provided in the canteen at 1 a.m. for the night shift, it will be eaten as readily as is a similar meal served at 1 p.m. to the day shift.

Vitamin A and Night Work

Vitamin A is present in liver, in eggs, in dairy produce generally and in the present vitaminised margarine. Green vegetables and carrots also provide vitamin-A activity to the diet by virtue of the yellow pigment, carotene, which they contain. If a diet is rich in vitamin A and contains more than is needed by the body for its daily life, some of it will be stored away in the liver. It is interesting to note that a rat can store up in its liver enough vitamin A to keep it going in health for 100 years. Since rats live for only about three years, this is a handsome margin. We can take it, therefore,

that people who have enjoyed an abundant diet as children need not worry unduly about eating carrots in later life. A child who never misses his spoonful of cod-liver oil from his early months up to five years of age will certainly start his career with vitamin A " in the bank ". On the other hand, there are very many people in Britain whose consumption of vitamin A is consistently less than their full needs. Professor Yudkin was recently able to pick out girl students at King's College, London, whose diets were deficient in vitamin A by making certain physical examinations of them.

One of the evidences of a shortage of vitamin A is a particular type of roughness of the skin of the upper arms and of the legs. Another indication is an inability easily to adapt the eyes to a dim light. This is the so-called night blindness. Clearly, any such handicap will be particularly serious for night workers. Although night blindness due to vitamin-A deficiency is not common, diets which are borderline in vitamin A are. It is therefore reasonable to recommend that caterers who are feeding night workers should take pains to include frequent and ample supplies of the foods which contain vitamin A.

Physiological Rhythm and Night Activity

Although the requirements of night workers for nutrients do not seem to be different from the requirements of day workers, night work itself influences the body in a number of ways which have from time to time been of interest to scientific investigators.

The normal twenty-four-hour cycle of day and night exerts a rhythm on a number of systems of the body. For example, the body temperature as measured by a clinical thermometer rises during the morning to a maximum usually in the after-

noon or evening, and falls again to a minimum during the night. As long ago as 1898, Johansson[1] suggested that the rise during the day was partly due to muscular activity and partly to the effect of the consumption of food. Some experiments carried out by Pieron[2] in Paris in 1913 suggest that this explanation is correct, at least in part. Pieron took the temperatures each hour or so of a number of hospital nurses, and found that when they had been on night duty for five or six weeks their temperature rhythm had become reversed. That is to say, it was highest during the night, and fell to its minimum by day when they were in bed. The length of time needed for this change to occur—five or six weeks—is, however, important. Benedict,[3] the famous American physiologist, failed to observe any inversion of temperature in an experiment of reversing the day and night activities of his collaborators for a period of ten days.

Before we pass on to our next point, it is, I think, interesting to review three more scientific experiments of a similar nature to those of Pieron in Paris. First, we might mention Lindhard. He was a Dane who in 1910 was in charge of an expedition which was spending the winter in Greenland. He investigated the effect of changing by twelve hours the meal-times of his crew. And he found, as we now know that he might have expected, that by doing so their temperature rhythms in due course adapted themselves to the new times. It is probable that few opportunities are more favourable to such an experiment than the Arctic night in Greenland. Similarly, Gibson[4] in 1905 showed that the physiological rhythm of the body will in due course change

[1] Johansson, 1898, *Skand. Arch Physiol.*, 8, 85.
[2] Pieron, 1913, " Le problème physiologique du sommeil ", Masson, Paris.
[3] Benedict and Snell, 1902, *Arch. f. d. ges. Physiol.*, 90, 33.
[4] Gibson, 1905, *Amer. J. Med. Sci.*, 129, 1048.

by twelve hours when people leave Britain and go to live in Australia.

Finally, we come to our third investigator, whose recent work is perhaps of more practical usefulness in helping us to solve the immediate problems with which we have to deal. This worker, Professor Kleitman,[1] first observed that among the members of the crews of ships which spend their time crossing and recrossing the Pacific Ocean, there are some who can quickly and happily adapt themselves during the eastward journeys to a series of shortened days, and during the westward journeys to a series of lengthened days. But while there are some men who can quickly become accustomed to these changes, there are others who cannot.

We have now come to one of the most important scientific factors affecting the feeding of night workers: whether or not they are physiologically capable of adapting themselves. Let us therefore follow Professor Kleitman one stage farther.

Having observed the differences in efficiency of ships' crews, he then decided to carry out some precise experiments. He and a colleague recorded their own daily and nightly temperature rhythms for a period of six weeks. Both of them had body temperatures rising to a peak of almost 99° F. each day and falling to 97° F. at night. They then arranged for themselves a twenty-one-hour schedule of work, meals and sleep. Under this arrangement they lived an eight-" day " week every seven days. But whereas one of them quickly developed an eight-period temperature rhythm, the other maintained his normal seven-period rhythm throughout the experiment. During a second six-week investigation the two men lived a twenty-eight-hour schedule which involved their going to bed four hours later each night and gave them a six-" day " week. Again only the more adaptable in-

[1] Kleitman, 1939, " Sleep and Wakefulness," Chicago Press.

dividual quickly developed a temperature rhythm to correspond, whereas the other did not.

After these two experiments had been completed, it was decided to try to assess to what extent noise, light and change of temperature during the twenty-four hours might have affected the results. Professor Kleitman and his companion therefore repeated the twenty-eight-hour schedule in Mammoth Caves, Kentucky, where it was perfectly dark, completely silent and always within a fraction of a degree of 54° F. The same results were obtained. By the time that Kleitman's colleague had established a rhythm of six temperature cycles a week, with a low minimum at the time he was at the end of his sleeping hours and a high maximum at dinner time, Kleitman himself obstinately clung to the seven-day cycle appropriate to his normal habits of eating and sleeping.

The sensitive mimosa plant continues its daily cycle of folding and unfolding its leaves for some time after it has been placed in a windowless room with the electric light left on all the time. The marine invertebrate, *Actinia equina*, which retracts its tentacles and closes its sphincter each ebb tide, will continue to do so for several days after it has been placed in an aquarium. Men also become accustomed to a daily rhythm which must be broken when they do shift work or night work. Although Kleitman's experiments are not directly applicable to the subject of diet, they are important in studying the problems of night workers. All the evidence shows that there are two kinds of people: those who can quickly change their daily rhythm and who can in consequence speedily adapt themselves to night-shift work, and those who cannot quickly acclimatise themselves. The efficiency of night work would probably be increased if such people were excluded from it, and particularly when the

frequency of change from night work to day work is comparatively quick. Since this to-day is beyond the bounds of practical politics, the caterer must remember that physiological unsuitability to night work may be the unconscious cause of some of the complaints he or she receives.

To summarise so far: if night-shift workers carry out the same tasks as people working on the day shift, and if their hours of sleep and play are approximately the same, then the only logical principle to be followed in feeding them is to assess their needs on the same basis as those of day workers. As we have shown, some people possess a physiological incapacity to adapt themselves quickly to night work, and these will be unhappy and unsettled no matter what is done for them.

Application of Scientific Principles to Practical Problems of Night Workers

Let us now consider how the scientific principles of nutrition can be usefully applied by the caterer to the practical problems of catering for night workers. The practical problems seem to me to be twofold: first, what sort of meals are required? and, secondly, what practices should the caterer adopt so that the meals he or she provides have the highest possible nutritional value?

Before trying to decide what type of meals suits any particular group of workers, it is first important to know something about their diet as a whole. It has been emphasised more than once that the day's diet *must* comprise certain known amounts of a large number of different nutrients. It is equally important to remember that these nutrients can be obtained from an infinite variety of foods and from a great diversity of dietary patterns. In different parts of the country and in different occupations, different meal-times,

different local dishes and different numbers of meals in the day are to be found. All of these variations *may* make up a nutritionally adequate diet, although they do not always succeed in doing so.

Let us look at a few of the actual dietary patterns found to exist in different industries. Coal-miners form an interesting example. At a certain mine in Leicestershire, the morning-shift people ate four meals a day: breakfast at 5.30 a.m., a "snap" at 11 a.m., dinner at 3 p.m. and supper at 8 p.m. Of these four meals only dinner was a hot meal.

Next there was the afternoon shift. The men on this shift ate breakfast at 8 a.m., dinner at 12.30, a "snap" at 6.30 and supper at 11 p.m. On this occasion supper was sometimes a cooked meal, as well as dinner.

Finally, there were the night workers. These men ate five meals: supper at 8.30 p.m., when they got up, a snack of bread-and-butter, cakes and tea at 10 p.m. before starting work, a "snap" at 2 a.m., breakfast at 7 a.m. and the family dinner at noon.

It is a useful exercise to consider how a canteen can best help this, our first example of night workers. It is often assumed that in almost any circumstances a cooked meal of meat, vegetables and sweet is better than a snack. We shall discuss this in more detail later. Meanwhile it is obvious that coal-miners present a special problem to the caterer because they cannot come to the canteen for a meal in the middle of their shift. This restriction is shared by certain foundry workers and others. It might be imagined, therefore, that the canteen ought to serve a full hot meal to the night-shift miners before they start work. This, however, is probably unwise, at least for underground workers in mines where the seams are low. For these men the bulk and weight of a hot meal are often more than their stomachs

can comfortably carry in the confined conditions of the coal-face. Without a hot meal from the canteen, however, these men are entirely dependent for the nutrients such a meal supplies upon the family dinner they eat at home at mid-day. Let us therefore review once more the principal differences in nutritional value between a cooked meal and a snack or sandwich meal.

Hot Meal *versus* Snack

The first point, which applies more forcibly perhaps to the night worker than to those working by day, is that a snack does not necessarily supply fewer calories. That is to say, its energy value is often equal to, or greater than, that of a hot meal. For example, two rounds of bread-and-dripping, containing, say, 5 oz. of bread and $\frac{1}{2}$ oz. of fat, will provide almost 500 calories, whereas a slice of roast beef with potatoes and greens will supply only about 300 calories. There may be an answer to the question one is often asked: "How can I be expected to work on bread and margarine?" but that answer cannot be based on energy values.

A properly cooked hot meal is nutritionally superior to most snacks in at least two respects. It usually contains more vitamin A, and it ought to contain substantial amounts of vitamin C, while most snacks contain none. If we cast our eye down the vitamin-C column of the analytical composition of the five meals eaten by our Leicestershire night-shift coal-miners, we see

(*a*) vitamin C in supper at 8.30 p.m.—nil.
(*b*) vitamin C in snack at 10 p.m.—nil.
(*c*) vitamin C in "snap" at 2 a.m.—nil.
(*d*) vitamin C in breakfast at 7 a.m.—nil.
(*e*) vitamin C in family dinner—32 mg.

Thus for the group to which the figures apply, *all* of the day's vitamin C was obtained from the single hot meal eaten.

The Value of Meat

A hot meal often (but not always) differs from a snack because it contains meat. The nutritional significance of meat was discussed in Chapter Four.

A Full Meal for Night Workers

Having glanced at the principal respects in which hot meals differ from snacks or packed meals, let us return for a moment to consider another example of the diet of night-shift workers. A group of men were first studied who were doing fairly heavy industrial work by day. Their hours were from 8 a.m. to 5.30 p.m. It was found that they ate six meals a day: breakfast at 6.30 a.m., a snack at 10 a.m., dinner at 1 p.m., another snack at 4 p.m., tea at 6 p.m., and supper, sometimes with a pint of beer, later in the evening. The main hot meal of the day was the canteen dinner. Upon this they depended not only for its contribution of calories, but for meat and, more particularly, for almost all of the vitamin C for twenty-four hours. In fact, it was up to the caterer to provide what we should describe as a "good hot meal". We will discuss in more detail what we mean by this in a moment.

In comparison with these men, we have an analogous group who were doing the same work at night. Their hours were from 11 p.m. to 8 a.m. These men also ate six meals a day: tea at between 6 and 7 p.m., a snack at 10.30 p.m., dinner at 1 a.m., another snack at 5 a.m. and breakfast on reaching home at about 8.30 in the morning. Most of them shared their families' mid-day dinner as well.

The timing of these meals is almost exactly the same as that of the day workers, except that one must read a.m. for p.m. and p.m. for a.m. And again, except for some vitamin C in the chips in fish and chips eaten at supper or in a tomato at breakfast, the whole of the twenty-four-hours' supply of this vitamin was derived from the canteen cooked meal at 1 a.m. Surely we must argue, therefore, that the nutritional value of this meal at night is just as important as that provided for men at mid-day.

It is not very useful to try to put up a target in terms of calories, protein and other nutrients for what we mean by a good canteen meal. It is almost sufficient to say: *A canteen main meal should include a well-cooked entree containing meat or fish, potatoes and at least one other fresh vegetable and a sweet, the whole supplying enough to satisfy appetite.* But this definition, while useful as a practical rule-of-thumb measure, is not scientific. If I were compelled to give a scientific target for a meal, I should say:

> "A good main meal for an industrial worker doing a job calling for a moderate amount of activity and able to obtain a mid-shift snack in the morning and afternoon (or at equivalent times on the night shift) should provide the following:
>
> 850–950 calories
> 35–45 g. protein
> 35–45 g. fat
> 1,000 i.u. vitamin A
> 30 mg. vitamin C."

We have now reached the point where we can come to grips with the problem: (*a*) *what sort of meals should the caterer provide for night workers?* When we have dealt with it we can proceed to problem two: (*b*) what practices should

the caterer adopt so that these meals provide the nutritional values the men need ?

To start with, then, I suggest that when night work in a factory involves the complete inversion of the habits of day work, and when the work done at night is the same as that done by day, then the same type of meals as those served by day and of equal nutritional value should be provided. That is to say, a hot meal of a nutritional value equal to the target we have just discussed should be made available. Those people who belong to the group who cannot adapt themselves to night work may not be able to eat such a meal, and such people may be more numerous where the shift-changes from night to day are quickest, nevertheless there is no clear scientific evidence to support the suggestion that night workers (under the conditions I have just defined) have need for less food. There *are* circumstances when less can reasonably be given, but it is very important to try to see the true facts affecting people doing on a night-shift the kind of work they do by day. It is fatally easy to argue that such men do not need a full meal, when what is meant is that it is inconvenient to arrange for them to get one. In similar circumstances, people argue that the fox enjoys fox-hunting.

The recommendation to provide a full hot meal of a nutritional standard detailed a moment ago applies to men doing in the night what would otherwise be, in arduousness and in timing, a full day's work. There are a number of circumstances which would change this recommendation. Among these are :

(*a*) unusual working hours ;
(*b*) workers' home meal habits ;
(*c*) work of varying arduousness.

The Effect of Shift Timing

A common night shift is from, say, 10 p.m. to 6 a.m. A full hot meal conveniently fits into this type of shift at, say, 1 a.m. Where, as is sometimes found, the night shift is from, say, 4 p.m. to midnight, or from midnight to 8 a.m., a different type of meal is clearly needed. For whereas the 10 p.m. to 6 a.m. worker will have a tea meal at 6 or 7 p.m. in the evening, and will thus depend on his canteen to supply a main meal at night, the man working from 4 p.m. to midnight will usually have a cooked mid-day dinner, and will not in consequence so urgently need to obtain the special nutritional contributions of a cooked canteen meal in the evening.

The Effect of Home Habits

The effect of home habits on the type of industrial meal required is similar to that arising from the study of factory hours, but it is in many ways even more fundamental to the success or failure of a canteen in its work of contributing to workers' nutrition. A microbe has need for certain nutrients, just like a man, but the microbe's nutritional wants are satisfied when its due diet is added to the broth in which it is swimming. A white mouse requires calories, proteins and vitamins just like you and me, but it will maintain itself in perfect health on a mixed powder of synthetic ingredients left in front of it all day in a pot. A man, however, is more than a microbe and something more complex than a mouse. He can suffer from primary malnutrition due to direct shortage of the nutrients needed for an adequate diet and he can also suffer from secondary malnutrition due to dislike of certain food, due to unhappiness and discontent or due to a disturbance of set habit.

Besides contributing to the nutrition of work-people, a physiological function, the canteen contributes also to their welfare, a social function. And welfare extends beyond the factory. As Mr. Noel Coward said : " An efficient ship is a happy ship." Similarly, to be efficient a workman must also be happy. And he will not be happy eating in the canteen if he wants to be at home. Hence, where the men get cooked meals at home with their families there is less need for the canteen to try to provide hot meals as well. In some localities, men working on night shifts get out of bed to share a cooked mid-day dinner at home. Elsewhere, on the other hand, where the women work as well, or for other reasons, the midnight canteen dinner is the workers' principal source of balanced nutrition. Thus, it is incumbent on the canteen manager who really wishes to apply scientific principles to industrial catering to know something about the home life of the men using the canteen, just as he or she must know something about their work.

Conclusions

The practical lessons to be learnt from the scientific observations reviewed in this chapter seem to be the following :

1. If night workers are called upon to do the same amount of work as day workers, their diet must be of equal nutritional value.
2. Night work involves a disturbance of the normal physiological rhythm. Certain people cannot quickly adapt themselves to this change of rhythm and in consequence they will tend to be restless and unhappy. The palatability and attractiveness of night meals, therefore, should be if anything better than those of meals served by day.

3. Snacks are an equally good means of supplying calories and most other nutrients as cooked meals. Cooked meals, however, more frequently supply vitamin A and vitamin C and may also include meat in its most palatable form; consequently, when the timing of night work is such that men would not obtain a hot dinner at home, one should be supplied by the canteen. When a cooked meal is obtained at home, the canteen may often more usefully concentrate on snacks and lighter dishes.

How, then, should the caterer, faced with the duty of feeding night staff, best proceed in order to supply their nutritional needs? First, I suggest, he or she should find out something about the work and the working hours of the men, in order to be able to plan the best type of meal to provide. If the evidence points to the need for a hot meal, this meal must be freshly cooked. There are two reasons for this suggestion. Firstly, only by this means can vegetables containing vitamin C be obtained. By no expedient of keeping hot or precooking and reheating can destruction of this nutrient be avoided. Secondly, the freshly cooked meal is more attractive and appetising. And here I should like to enter a plea for fresh-cooked meat. There is no evidence yet acceptable to a scientist to prove that roast meat made cold, then carved and reheated with gravy has lost in nutritional value. Yet in the light of tentative new facts about the "animal protein factor" in meat and, most particularly, because of the loss in flavour inseparable from this practice, I would suggest its abandonment wherever possible for night-shift workers at least. They are often fewer, and some whose rhythm is disturbed need tempting.

The final point, then, is, that after thought has been given

to the day's total calorie requirements, to protein, vitamin A and vitamin C and to the balance of the different meals of the day, then, and above all, let the caterer make sure that the meal is attractive, well cooked and well served. Human nutrition is something more than the study of the physiological wants of the human animal; it is also the study of men and women.

Chapter Thirteen

ADOLESCENTS

ADOLESCENCE gives rise to a number of special problems. The adolescent is the ugly duckling. He is the link between the schoolboy and the fully fledged workman. His noisy self-assurance or his abashed awkwardness, his voice fluctuating, in the words of Dickens, " between an unearthly treble and a preternatural base ", are indications of the physiological changes which are taking place within his person. These changes are accompanied by certain changed and mostly increased requirements for food. For the adolescent in industry it is at the time when these special needs exist that he ceases to obtain his school meals and his school milk and simultaneously becomes exposed to a whole variety of physical and emotional stresses inseparable from his finding himself at work.

Definition of an Adolescent

In defining an adolescent, it is convenient to follow the classification adopted by Professor Richard Ellis of Edinburgh University.[1] Professor Ellis recognises three stages of development: (*a*) *non-pubescent*, when no developmental changes have occurred, (*b*) *pubescent*, when some but not all of the signs of developing maturity are to be seen and (*c*)

[1] Ellis, 1947, *Edinburgh Med. J.*, 54, 269.

adolescent, when genital development is well advanced but full physical maturity and growth have not yet been achieved. These changes take place in boys, between the ages of, say, eleven and seventeen years. In girls development occurs earlier.

Among the most important measurements of nutritional status are height and weight. It is common to assess the adequacy of the feeding in a school by the growth achieved by the children. When it is not possible to measure the *increase* in height or weight over a period, weights or heights are often compared with standards. This is of dubious value, because the averages upon which standards are based change quite quickly. For example, the most familiar and the most unreliable way of deciding whether our diet is adequate or not is to weigh ourselves on a station platform and compare the figure with that listed as " standard " on the machine.

It used to be a commonplace that boys educated at private schools were head and shoulders taller than their contemporaries educated at national schools, due to the better nutrition enjoyed by the former. Although the tendency over the last thirty years or more has been for children at national schools at each age to become continuously larger and larger, boys at Christ's Hospital school, for example, are still better fed on the average, and hence bigger, than those of the same ages measured by the London County Council.

Professor Ellis, however, has made two important contributions to the interpretation of such figures of heights and weights. Firstly, instead of taking the average of the records of all the children weighed at each age, he sorts each group into three and compares those in the *non-pubescent*, the *pubescent* and the *adolescent* stages. When this is done, it is found that a great surge of growth takes place as puberty

develops. It is this rapid growth and radical change in maturity that give rise to the greatly increased nutritional needs which we are going to discuss in a moment. At each age in this period, which for boys lies between eleven and eighteen years, the pubescent boys are bigger than the non-pubescent and the adolescent than the pubescent. Indeed, three graphs can be drawn for the increase of height and weight with age : the adolescent line at the top, the pubescent next and the graph for non-pubescent boys lowest of all.

Professor Ellis' second observation, which makes the drawings of these three graphs possible, is that at each age individuals differ markedly in their degree of maturity. It is consequently reasonable to assume that they also differ equally widely in their dietary requirements. This phenomenon presents a practical problem to those responsible for the nutrition of young persons. Some figures are of interest here. A large group of 662 boys was studied. Among those of fourteen years of age, 30% were non-pubescent, 40% were in the intermediate pubescent stage and 30% were fully adolescent. One year older, only 5% of the fifteen-year-old boys were non-pubescent, whereas 62% were adolescent. And at sixteen years of age 2% were non-pubescent compared with 73% adolescent. Thus, the raising of the school-leaving age from fourteen to fifteen years will reduce the number of boys who enter industry at the nutritionally difficult period when the rapid and radical changes of puberty are occurring.

Nutritional Requirements

This is the background of fact which we must carry in our minds when we consider the nutritional needs of adolescents and the way in which these needs differ from those of other

categories of workers. In discussing these nutritional requirements we can do no more than consider average figures. Nevertheless, we must remember that adolescents as a group are not homogeneous; at each age we have to deal with children, with those half-way across the border and with the full-blown adolescent himself.

Calories

First, calories. Calories it will be remembered are required for two main purposes: for the maintenance of the body processes, the circulation of blood, breathing and for the maintenance of the tension of the muscles. For these purposes, commonly called "*basal metabolism*", a man between twenty and thirty requires about 40 calories an hour for each square metre of body surface. A developing boy of eleven, on the other hand, uses between 40 and 50 calories per square metre per hour, depending on his state of development. Throughout the years of growth, up to eighteen years old or so, the basal metabolism of an adolescent exceeds that of an adult by 10% or 15%.

The fact that the calorie requirement depends not only on the *basal metabolic rate* but also on body-size makes the feeding of adolescents doubly difficult. It is commonplace that the size of young people of the same ages may differ enormously. For example, the standard American height–weight tables[1] show that one normal fourteen-year-old boy may weigh 72 lb., whereas another equally normal boy of the same age may weigh more than twice as much: 148 lb. The *average* given for this age is 108 lb. On theoretical grounds, if the average energy requirement of the fourteen-

[1] Baldwin and Wood, 1923, "Weight-height-age tables for boys and girls of school age", American Child Health Ass., New York.

year-old *group* is 3,200 calories, the big boy will need 3,500 calories and the little one 2,700.

When we are considering the food requirements of a whole category of people, we *have* to talk in terms of average needs, but this single example, considered in the light of the facts associated with growth and the development of maturity, shows how important it is also to remember that individuals may differ very markedly from the average.

The second function of calories other than that of maintaining the basal metabolism of an individual, of whatever size he may be, is for the performance of muscular work. A man of average size requires 70 calories an hour for basal metabolism: that is, to lie still and warm in bed breathing. As soon as he moves and gets up he begins to do physical work, and his calorie requirements increase. Even to sit calls for 15 calories an hour, in addition to the metabolic needs.

Dr. Widdowson,[1] of the Medical Research Council, found that the average calorie consumption of a series of groups of twenty boys between the ages of fourteen and eighteen years was between 3,000 and 3,400 calories daily. The U.S. National Research Council (see Table 1) recommend an allowance of 3,200 calories for boys between thirteen and fifteen and 3,800 calories daily for boys between the ages of sixteen and twenty years old. This places adolescent boys second in their demands for energy of all other categories. They are above nursing mothers, moderately active men, girls of fourteen (whose development occurs sooner than that of boys and whose maximum demands occur at that age), expectant mothers and all the other categories of housewives and children. In short, adolescent boys need more to eat than every other class with the exception of the heaviest industrial worker.

[1] Widdowson, 1947, Med. Res. Council, Sp. Rep. Ser. 257.

In planning meals for adolescents, therefore, we must remember that, quite apart from their needs for vitamins or any other protective factor, which we shall discuss in a moment, they have a high requirement for calories: that is, they need a lot to eat! How much, depends not only on what they are, but also on what they do: in other words, on their activity.

Protein

The second special nutritional need of the adolescent is for protein. We have already observed that the period of puberty and adolescence is one of rapid growth. Between his fifteenth and seventeenth birthday a boy may expect to put on 20 lb. in weight and to grow more than 2 inches taller. In order to do this, the U.S. National Research Council recommend that he should eat 100 g. of protein a day. This puts him in the highest category, bracketed top with the nursing mother and exceeding in requirement the expectant mother, the adolescent girl, the heavy worker and all other groups.

These are two of the respects in which the adolescent is known to possess materially increased nutritional requirements: for calories and for protein.

Calcium

The need of the adolescent for calcium is also greater than that of an adult, although less than that of a nursing or expectant mother. Since calcium is one of the building stones of bone, the need for it is obvious in view of the 2 inches in growth which the boy needs to achieve during his adolescent period.

Iron

The requirement for iron, from which blood is formed, is also thought to be disproportionately large. Here, for the first time, the needs of the adolescent girl are equal to or greater than those of her brother.

These requirements, for calcium and for iron, are greater for adolescents than for full-grown men and women, no matter what is the activity or rigour of the adults' work.

Vitamins

Finally, although here our knowledge is less precise, it is generally accepted that young persons, particularly developing boys, have increased needs for vitamin A and for vitamin C, the protective factors in green vegetables, fruit and dairy produce. In these requirements, again, they exceed all other groups except the expectant and nursing mother.

The Results of Under-nutrition

Before we try to see how those who are concerned with the feeding of the adolescents in industry can contribute to their special nutritional requirements, it is of interest to consider at least one of the effects which result from an *inadequate* diet. The commonest inadequacy is for a boy or girl to obtain too little to eat. This deficiency in quantity is often associated with insufficient protein.

Too little to eat restricts the output of work and causes loss of weight in adults. In adolescents it slows down the normal rate of growth and delays puberty. An interesting observation was made on this matter by Professor Ellis. He noticed that in Belgium whereas telegraph boys between the ages of fifteen and seventeen years were shorter and lighter

in 1944, when there was insufficient to eat, than those of the same ages in 1938–39, principally because puberty was delayed, the heights and weights of the more mature adolescents of eighteen and nineteen were almost normal. That is to say, an inadequate diet holds back the less mature young people.

We can now summarise the problem we have to solve. So far as nutritional requirements are concerned, the adolescent requires more calories than an adult doing the same job and, in addition, needs more protein, more calcium and iron and probably more vitamin A and vitamin C. Translated into terms of food, this means that the average adolescent needs bigger meals or more frequent meals; more milk and cheese; and more green vegetables, dairy produce and liver.

Social Aspects of Adolescents' Nutrition

Adolescents seldom take any intelligent interest in their diet. They are making their way in a boisterous and difficult world. If the money they have to spend is scanty, they save on food. If it is plentiful, they spend it on amusements rather than on their meals. It is for those who are professionally concerned with the diet of adolescents in industry to see how best they can obtain what they need.

Dr. Sheldon, when studying old people in Wolverhampton, showed that it is not enough to study an individual by himself. If you want to know *why* he eats the way he does—why, in fact, his nutritional state is what it is—you must study him in the environment of his family. The problem is the same for adolescents. When these words were being written, I was associated with a number of colleagues in investigating two large groups, one in England and one in

Scotland.[1] In both places we found that, of the diets of two adolescents working side by side, one might be satisfactory and the other bad. The first boy, let us say, lived in a united family, all of whom sat down to a meat tea at the end of the day, while the second brought sandwiches for lunch and snatched a hurried meal in the evening before going out courting or to night school. These human factors all affect nutrition.

Calories, proteins, vitamins and the like enter into the design of the meals served in industrial canteens; but a fundamental truth of the science of nutrition is that food, in order to exert its nutritional functions, must be eaten. And if it is to be eaten it must be well cooked and attractively served. Furthermore, it must be served in a place sufficiently attractive, in one way or another, to persuade the adolescent to go to it. The question of the attractiveness of the canteen is something that goes very deep. For example, one of the adolescents in our survey was eating a poor diet. We found that she—it was a girl—never used the canteen, where she could have obtained a good meal which she could easily have afforded. We asked her why she always went home. " Mother likes me to ", was the answer.

In some factories this aspect of the problem is being approached by arranging for parents to visit canteens to see what they are like and what kind of meals they serve.

The Caterer and the Adolescent

The nutritional function of the factory canteen in feeding the adolescent is (*a*) to provide a dietary supplement which shall be an addition to the food supply of the worker and

[1] Kitchen, Passmore, Pyke and Warnock, 1949, *Brit., J. Social Med.*, **3**, 10.

hence of his family and (*b*) to provide a basic contribution to the many diets, some good, some bad, eaten by the adolescents working in the plant, so that their total food consumption shall fill their nutritional needs. This function is the same as that originally propounded by Professor Schioz in Norway in the design of the Oslo Breakfast. This meal was planned as a supplement for schoolchildren whose diets, while sufficiently supplied with calories, were deficient in vitamins and protein.

The dietary needs of adolescents in industry here and now are not the same as those of the Oslo schoolchildren in 1931, but they are not entirely dissimilar. First, the adolescents in the factory need a supplement of calories; that is to say, we must insure that they have fully enough to eat.

How can supplementary calories most easily be administered in an industrial canteen? We have discussed the fact earlier, that fat is the food above all others which contains the greatest number of calories in a unit weight. Indeed, an ounce of fat, say margarine, provides 218 calories, which is equivalent to 10 oz. of potatoes or 2 lb. of cabbage! Next in calorie value to fat comes, say, a carbohydrate food not containing an undue proportion of water. Flour, for example, provides about 100 calories per ounce and sugar 108, whereas herring, a valuable food in its way, contributes only 50. Thus, if we wish to provide calories without fuss, we can mix *flour and margarine* together, say, in the form of *bread and butter* or, perhaps, a buttered bun, or even a piece of cake!

It is not suggested that bread-and-butter or bread-and-jam constitute a balanced diet: they do not. But we are aiming now to provide supplementary calories, and a buttered bun or a cheese roll does this more compactly than a full meal. For our adolescents, therefore, who need calories we can recommend supplementary mid-shift snacks.

Two other of the special needs of adolescents are for protein and calcium. The ideal combined source of these two nutrients is milk. Milk as a drink; dried milk in cocoa; milk in junket; cheese—all are equally valuable when provided in equivalent quantities.

The last of the special requirements of adolescents, for vitamins, can best be considered in the context of the total diet. A human diet, like that of an experimental rat, must contain its specific nutrients, but it must also be capable of being made into *meals*. Vitamin A is contained in green vegetables, carrots, liver, eggs and butter; vitamin C in fruit, potatoes and vegetables. The caterer can supply these in a balanced meal, containing the items he or she knows will be attractive to the customers and also containing vegetables cooked in such a way that their value is not destroyed.

Conclusions

The scientist and the caterer who look beyond their own immediate job are faced with the same problem. Neither of them is dealing with the whole of the matter with which they are both concerned. The scientist who considers human nutrition to be merely a branch of biochemistry can only speak of calories and nutrients. The caterer who limits himself to his trade is preoccupied with steam-jacketed pans or the lubrication of the Hobart mixer. Both the scientist and the caterer must know their jobs; but if they are to succeed fully they must take a wider sweep and accept that they are dealing with human kind—people whose lives, for good or evil, are passing away; people who are influenced by hopes and fears and likes and dislikes, economic motives, altruistic motives, love, or just by sheer cussedness. In fact, nutrition and catering are part of industrial health, and

industrial health deals with the whole man and the whole woman whose paths bring them into industry.

The technical points which have emerged from our discussion of adolescents in industry are :

(*a*) that their need for calories and for protein are greater than those of adults in corresponding walks of life. We have suggested that these needs might in part be filled by supplementary mid-shift snacks ;

(*b*) adolescents require calcium in order to enable them to achieve the lengthening of bone associated with growth. Milk or cheese will supply this supplementary need ;

(*c*) they require a balanced diet containing plenty of the protective factors from fruit and properly cooked vegetables. Towards this the canteen can contribute a basic foundation.

These are our technical conclusions about food. About the adolescents themselves, we have seen—and this I believe to be the fundamental point—that individuals differ. The conversion of boys and girls into men and women is partly affected by diet. But there are other factors than diet. Some children mature earlier than others, for genetic reasons. Individual requirements therefore vary.

Adolescents are a *group* about whose dietary needs we can reach certain general conclusions. But the adolescent we feed in the canteen is also an *individual*, with his individual requirements. This is not all. Ultimately he or she is a part of a family group. The caterer, bearing in mind the nutritional requirements of all adolescents and the individual needs of those who come to his canteen, must also appreciate the social needs of the individual as a part of the factory life and also as part of a family. In assessing

these social needs, the price of the meal, its time, the attractiveness of the canteen and all the other practical factors which influence an individual all play a part before the nutritional value of the meal itself can properly be discussed.

Modern life in an industrial country presents many difficulties for the individual. Where there is a large industrial unit, it is hard to avoid treating a person as if he were merely the number he appears to be on the time-clock. For the adolescent this difficulty is particularly great. To himself, in the midst of a period of rapid physiological change, he is something more than just another ticket at the service hatch. There side by side we see two fifteen-year-olds, one tall and gangling with a throaty baritone and a moustache, the other little more than a shrill schoolboy in overalls. Let us treat each one as the individual person he is.

Chapter Fourteen

LIKES, DISLIKES AND NUTRITION

IT is the object of this book to show that the nutrition of workers in industry depends on the intake of the nutrients to be derived from foods in those amounts known to be needed by people of a stated age, sex and activity. We have seen that the behaviour of individuals varies. Nevertheless, it is basic to the whole principle of scientific nutrition that the laws of physiology hold without exception for all groups.

In practice, however, men do not behave in the factory like experimental animals in the laboratory. If they do not like their food they will not eat it, and if they eat insufficient for their needs they cannot perform muscular work with full efficiency. Obviously, therefore, it is to the interest of the industrialists, to the social worker and to the economist to study the likes and dislikes of work-people, so that what they eat shall supply their nutritional requirements.

"A little of what you fancy does you good," says the music-hall song. This is because if you "fancy" it, you eat it. The other popular aphorism, that "you can lead a horse to the water but you can't make him drink", is equally true. A canteen can be established in a factory; but if there is freedom of choice for the workers, they cannot be persuaded to use the canteen unless they choose to do so.

Macrae [1] has set out a number of the psychological factors

[1] Macrae, 1947, *Nutrition, Dietetics and Catering*, 1, 104.

which affected the reactions of British airmen during World War II to the catering provided for them.

The presentation of meals markedly affects their acceptability. The colour of foods, their arrangement on the plate, the general appearance of the crockery and cutlery, the decoration and furniture of the dining-room are all important. It is a common mistake to imagine that because men and women work in overalls at a dirty job, a dirty, rough canteen will be good enough for them.

It is not proposed in this book to discuss the finer points of cookery and their influence on appetite and hence on food consumption, but they are obviously very important. As Macrae has pointed out, a well-cooked meal, well presented, may be more appreciated than a meal of higher nutritional value badly served. On the other hand, it must be emphasised that even if a particular food is disliked, it will be digested and absorbed and it will exert its appropriate effect on the nutritional state just as effectively as if it were popular—so long as it is eaten and not wasted or refused. Generations of children have disliked rice pudding, have been compelled to eat it and have benefited therefrom.

The principles of nutrition which have been reviewed in the earlier chapters of this book are based on observed and experimentally reproducible facts. Ultimately the failure of a group of individuals to obtain their nutritional needs is followed by the appearance of signs of one or other of a number of varieties of physiological breakdown. Although subjective dislike of a diet may be evidence of its unsuitability, it is by no means automatically so. Macrae gives a number of examples of purely psychological effects which influence people's reaction to their diet. For example, the most striking observation in R.A.F. messes during the war was that the acceptability of food bore little relationship either

to the actual quality of the meals or the precise method in which they were presented. When men and women were far removed from the fighting, they tended to grumble about their food, even if the catering was impeccable and the food itself adequate. When active operations were in progress, and particularly when they were succeeding, there were no complaints, even if the food itself was meagre and monotonous and the service rudimentary. Again, food which was refused or only grudgingly accepted when it was provided free by the official mess, would be paid for and enjoyed when it was made available at an outside canteen.

Other factors which improve the acceptability of communal meals are the possibility of making a choice of dishes and the manifestation of an interest in the catering by those responsible for it.

The final proof of the fallibility of the " little-of-what-you-fancy-does-you-good " approach to nutrition is that, although dietary habits change slowly, they can be, and are, changed. Working men who might claim at home that industrial production would be impossible without, say, fish and chips, may find themselves employed abroad where the dish is unknown. Durham miners who swear that cheese is " binding " can eat quantities of it if they go to work in South Wales. The list could be continued indefinitely. " There's nothing good or bad but thinking makes it so."

But although the strictly physiological argument can neglect dietary habits, the practical nutritionist cannot. Indeed, this book has attempted to set out within a limited scope how nutritional principles apply to the feeding of industrial workers in the environment of the nineteen-forties.

Final Recapitulation

Primarily, the foods of the diet provide the industrial

worker with calories for energy in proportion to the amounts of carbohydrate, protein and fat they contain. The body uses calories (*a*) for basal metabolism. The calorie requirement for basal metabolism, although it may vary by about 15% about the mean for individuals with higher or lower basic levels, is in general proportional to body surface. That is to say big people require more calories to keep them going than small people. It follows, further, that when big men obtain too little to eat they become thin, and when they are thin their body-weight is less than it was before, and consequently the amount of calories they require to maintain their reduced weight is less than that needed to support their original weight.

While the maintenance of body-weight is the first charge on the calories from the diet, (*b*) the second use for energy, is the production of work. The average demands per hour of many different types of activity have been studied and are to be found in the scientific literature. Hence, the average daily demands of different industrial occupations can be estimated. Experimental observation of the calorie values of the diets freely chosen by a number of types of industrial workers broadly confirms the theoretical figures. Equally well-established observations show, however, that the efficiency of different *individuals*, and hence their calorie demands for the same job, may be very different from the average.

Although some 36% of the dietary calories in Britain are derived from bread and flour and only 15% from fat, the latter is a nutrient of particular significance to heavy industrial workers because it provides calories in higher concentration than any other substance. In order that a man may be able to find room in his stomach for the fuel to supply, say, 4,500 calories daily, it has been thought reason-

able to suggest that 35% to 40% of the calories, *i.e.* 1,575 to 1,800 calories, should be derived from fat. This would be achieved by the consumption of 175 g. to 200 g. of fat daily. It is immaterial nutritionally how much of this amount is contributed by butter or fat or oil as such, by the fat of meat or milk, or by that in fish and chips.

If industrial workers do not like their meals and in consequence do not eat them, they will obtain insufficient calories for their needs and their working efficiency will suffer. Meat is a popular article of diet; it contributes substantial amounts of fat to the diet and, therefore, partly on this account and partly on account of its psychological effect of encouraging the consumption of other foods, it plays an important part in industrial nutrition. Repeated efforts have, however, failed to provide clear objective evidence to prove that meat is physiologically essential for the production of muscular work.

Protein, of which meat, along with dairy produce, fish and other animal and certain vegetable and cereal foods, is a good source, is needed for the maintenance of the tissues of the body. Adolescents have a special requirement for protein for bodily growth. In general, however, an industrial worker who obtains sufficient food to supply his needs for calories cannot fail to receive adequate amounts of protein and to spare. Although many experiments have been carried out, none has shown that added protein improves physical performance.

When we pass from the consideration of calories, fat and protein to that of other nutrients, we must first review the available information of the amounts of calcium, iron and other mineral substances and the quantities of a diverse and numerous series of vitamins all of which are essential for normal physiological well-being.

Some of these vitamins, at least, play a special part in the nutrition of industrial workers. Deficiency of vitamin A, in so much as it affects the power of the eye to adapt itself to low levels of illumination, could be specially harmful to workers such as miners, railwaymen or lorry-drivers who need to work in a dim or fluctuating light.

Deficiency of vitamin B_1 produces a loss of appetite and may therefore lead to a failure of workers to eat a diet of sufficient calorific value for their needs.

The importance of a knowledge of the properties of vitamin C to anyone responsible for the nutrition of people in industry arises from the ease with which the vitamin may be destroyed in large-scale catering.

While an appropriate intake of each of the several vitamins is essential for the maintenance of workers in normal health, there is no evidence that an excess—in the form, for example, of vitamin pills—will in any way improve industrial efficiency.

The nutritional principles affecting physical well-being have to be applied within the framework of the practical conditions of industrial life. First, before nutrition can be brought to bear on the workers at all, allowance must be made for a series of losses ranging from the deterioration and loss of, say, fish at the docks or vegetables at the market, through kitchen waste and spoilage in the canteen and including loss during cooking of a proportion of one or other of the vitamins from heat or oxygen from the air. Good cooking and service are of enormous significance in nutrition. Where they exist, meals are eaten; where they do not, they are not.

Men doing very exhausting work may find that their blood becomes deficient in glucose, the fuel for muscular work. Since the blood-glucose level rises after a meal, it is logical

for such workers to eat frequent meals throughout the day. We have seen, however, that for workers less strenuously employed the number of daily meals is less a matter of physiological significance than a question of custom. For those responsible for providing industrial meals a knowledge of local custom is therefore important, in order that the type of meal provided shall most effectively supplement the remainder of the day's intake, so that the whole shall constitute a nutritionally adequate diet.

One of the commonest arrangements appears to be for industrial workers on a normal day shift to eat six daily meals. Of these, three are usually provided during the working hours. The so-called snack meals play an equally important part as the mid-day hot meal and, in consequence, the nutritional balance of such meals needs as careful scrutiny.

We have seen that workers in light industry may, in fact, comprise those whose energy demands are great as well as others whose needs are small. Indeed, it seems to be a general physiological principle that although the *average* energy requirement for any particular type of work can be determined with reasonable precision, the needs of an *individual* may vary by 100% or more from the average.

Heavy workers require a diet high in calories. In order that such a diet shall not be unduly bulky, the proportion of fat in it must, as we have seen, be enough to provide 30% or more of the total calories. Frequent meals, besides helping to maintain a desirable level of glucose in the bloodstream, also serve to overcome the problem of dietary bulkiness. When, however, we study the dietary habits of coalminers, who may be taken as representative of one type of heavy workers, we find some who customarily eat four meals a day, some who eat five and others who eat six daily meals.

Coal-miners appear to cling tenaciously to local dietary habits, of which a liking for or a dislike of cheese is one. The number of daily meals may not be entirely due to habit, but may also be affected by the timing of the shifts. Nevertheless, there appears to be scope for the application of the nutritional principles which we have discussed to the actual conditions of the coal-miner's life. The preparation of the "snap" meal has, indeed, been given much attention, and in some parts of the country factories exist for the mass production of packed "snap" meals, which are then distributed to surrounding miners. One problem is the selection of foods to compose these carried meals, so that, besides supplying calories, they may also provide vitamin A, vitamin C and other protective factors.

There are a number of reasons for thinking that outdoor workers may be called upon to expend more physical energy than people engaged upon any other type of activity. The greatest calorie output of which reports are to be found in the literature is that of American lumbermen, whose requirements were in 1904 claimed to be more than 8,000 calories! Lumber workers in Northumberland in 1944 were estimated to consume 4,600 calories. In unconscious conformity with the principle developed in this book, these men ate the food they carried with them into the woods in the form of three separate meals. The total number of meals in the day was thus brought to six.

The application of scientific principles of nutrition to the feeding of industrial workers is most difficult in practice when the normal dietary customs upon which the whole daily rhythm of the individual is based have to be thrown out of gear by the necessity for shift work. It is then that skill and the application of scientific knowledge can gain the greatest benefit.

The efficient functioning of every industrial worker depends on the nutritional principles which have been outlined in these pages. In two ways, however, scientific knowledge, although essential for any sure progress towards nutritional health and vigour in the future, is not enough. First, the rules of nutrition, which have been built up progressively since the time of Lavoisier in 1790, hold rigidly for groups of individuals of different sex, age and degree of activity; but within these groups individuals may vary widely in their individual needs and behaviour. A system of communal feeding must therefore always retain an element of flexibility.

Secondly, and lastly, men and women, in industry or out of it, are people, not experimental animals. It is true that they will grow thin and inefficient if they do not consume sufficient calories, that they will become unwell if they do not eat enough vitamin C. But they may *choose* to consume insufficient calories and to eat inadequate amounts of vitamin C—if they do not like their canteen (and many people would never eat in a crowd if they could avoid it), or if they are unhappy, or angry, or simply cantankerous. The best balanced diet does nobody any good if it remains uneaten.

People do not ingest calories and nutrients; they eat meals. This is the kernel of the psychological problem which lies behind the application of scientific principles to industrial nutrition.

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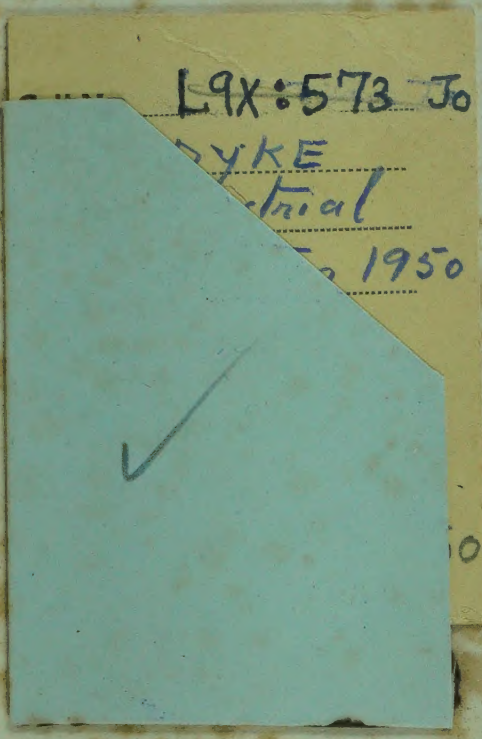
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